FOREST PRODUCTS JOURNAL

FOREST PRODUCTS RESEARCH SOCIETY

1960 YEARBOOK

TYPICAL OF CANADA'S CORDIAL WELCOME TO FPRS was the Mayor's Reception. Here, E. S. Harrar, the Honorable Sarto Fournier, Mayor of Montreal, R. H. Berry, and Mrs. Berry look on as Mrs. Harrar signs the Mayor's guest register.

YEARBOOK SECTION

President's message, report of 14th Annual Meeting, official statement of FPRS Policy, convention highlights, Division and Section reports, directory of more than 160 officers and committee members.

TECHNICAL SECTION

Twenty National Meeting articles on wood flour and foams, plywood, particle board, adhesives, preservatives, standards and specifications, wood-moisture properties, cutting fundamentals, and industry-education.

Vol. X, No. 10 1960/OCTOBER

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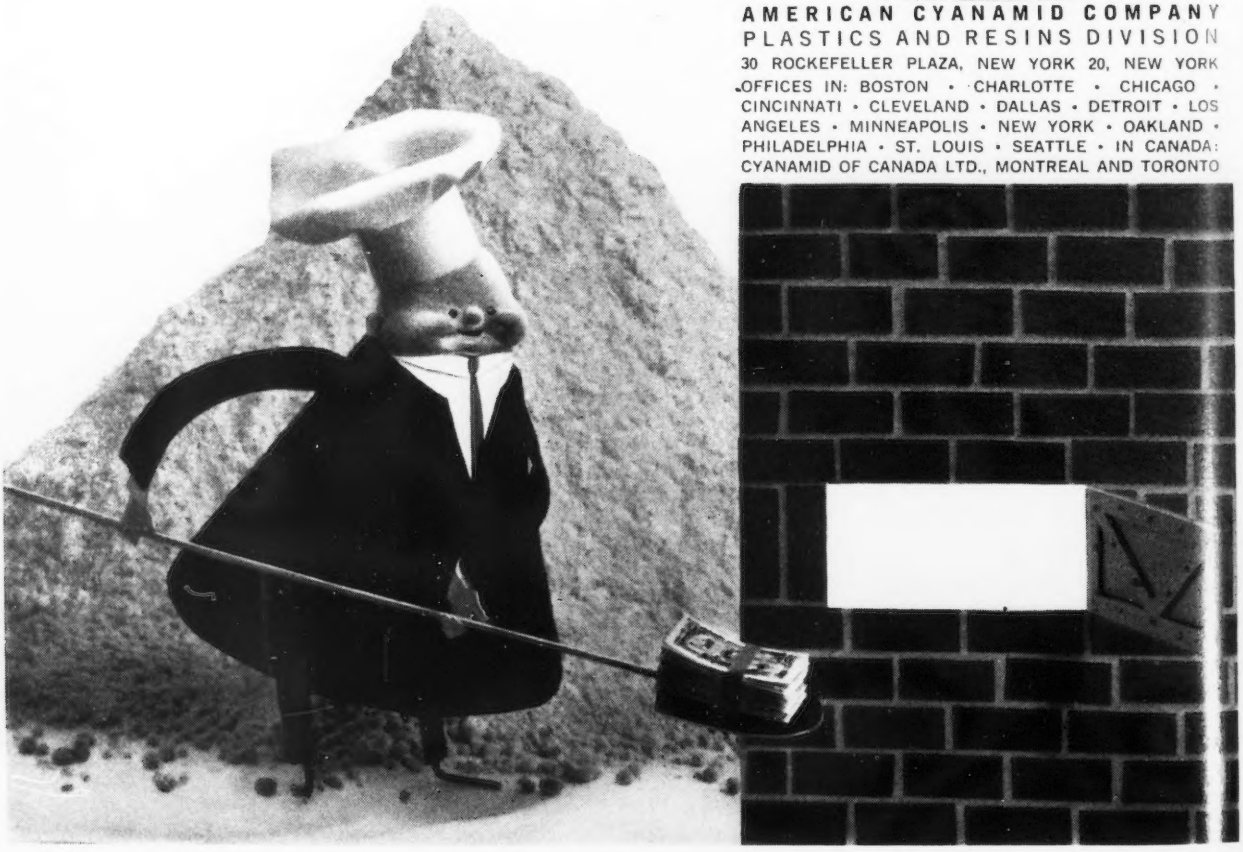

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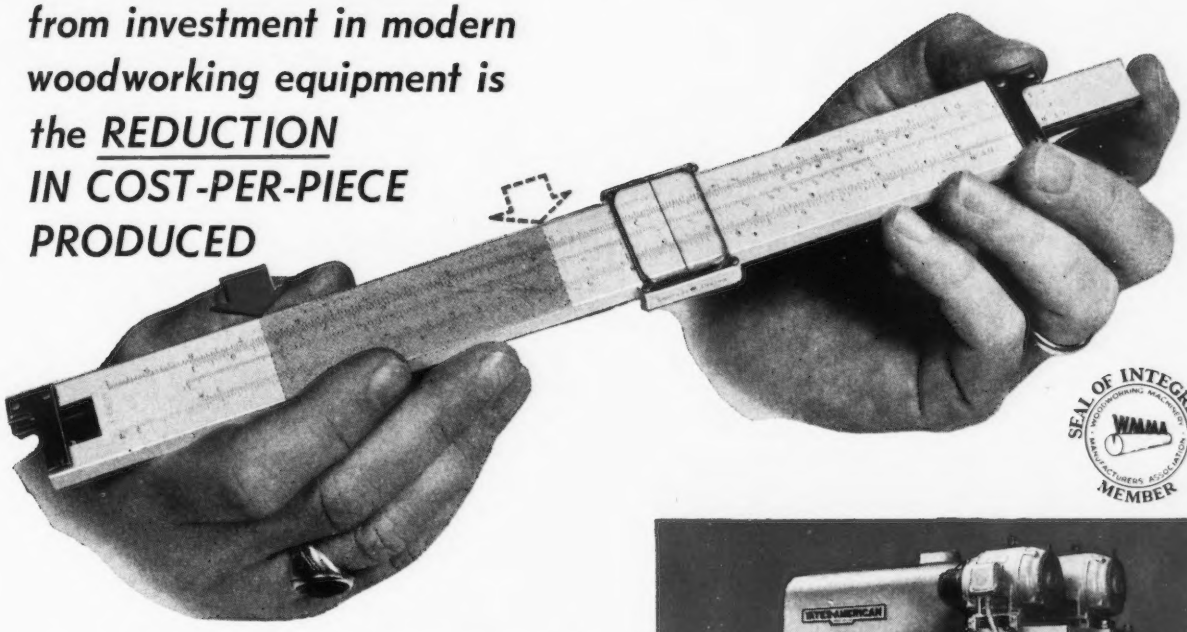

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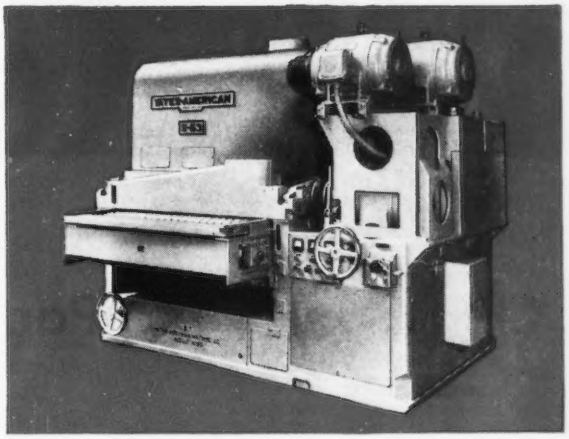

Profits are established on the basis of the cost-per-piece produced. Investment in modern equipment that results in increased production volume or lowered production cost automatically reduces the cost-per-piece . . . and increases the profit. This increase measures the *Savings* resulting from the investment.

For example, the Model S-53 combination Drum and Belt Sander finish sands at speeds up to 90 feet per minute—*three times faster than the conventional drum sander* . . . and the improved finish obtained eliminates over 90% of the stroke sanding operations that ordinarily follow. At the same time the selective contact shoes for the sanding belts on the S-53 provides the proper pressures to produce the finest finishes — resulting in substantial improvement in the product.

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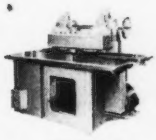
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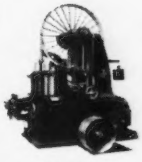
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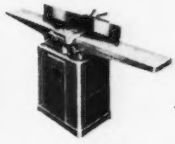
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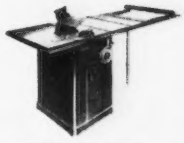
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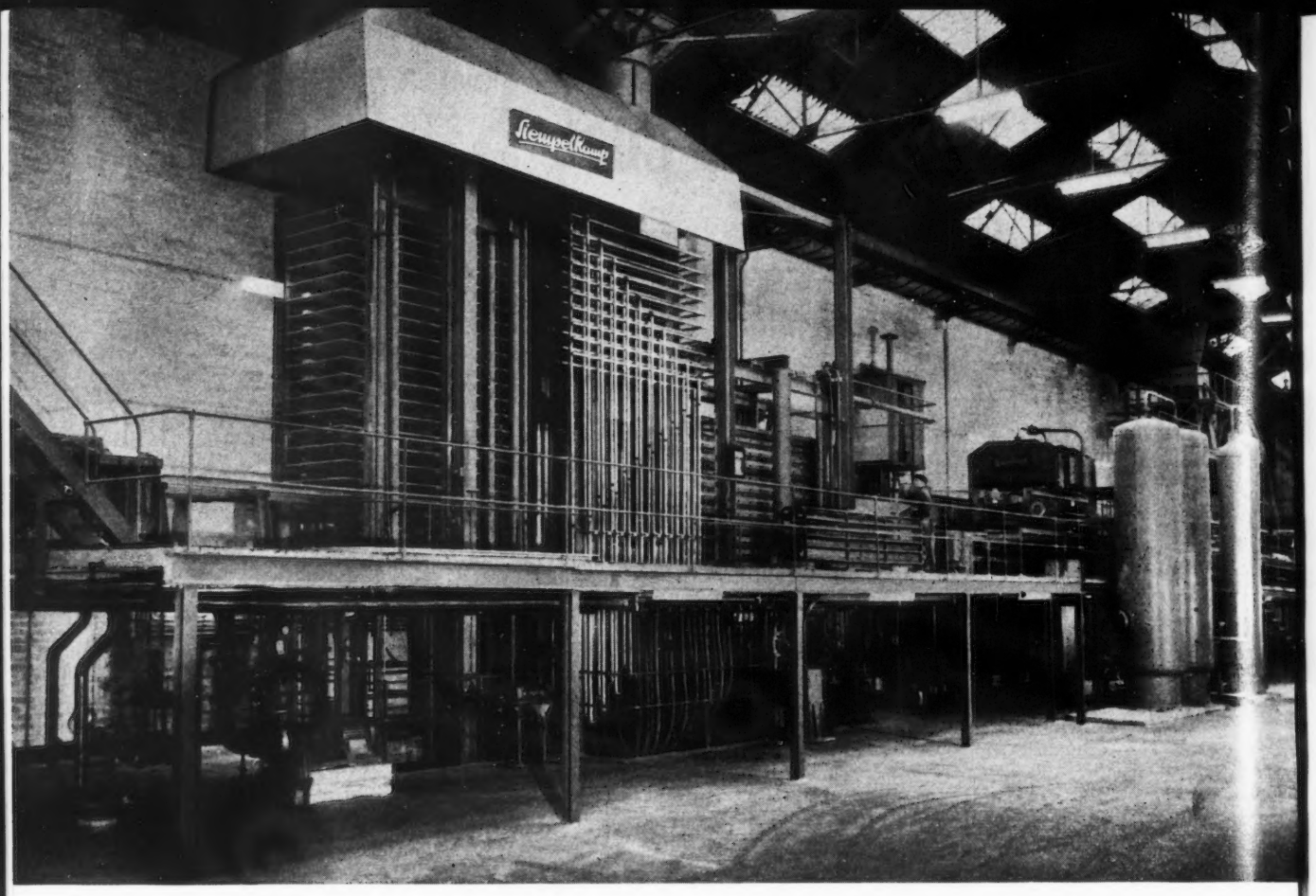

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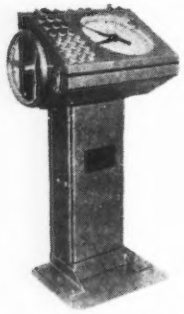

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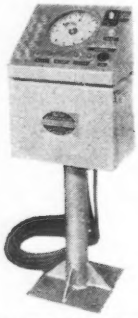

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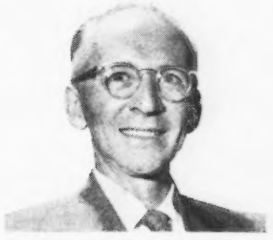

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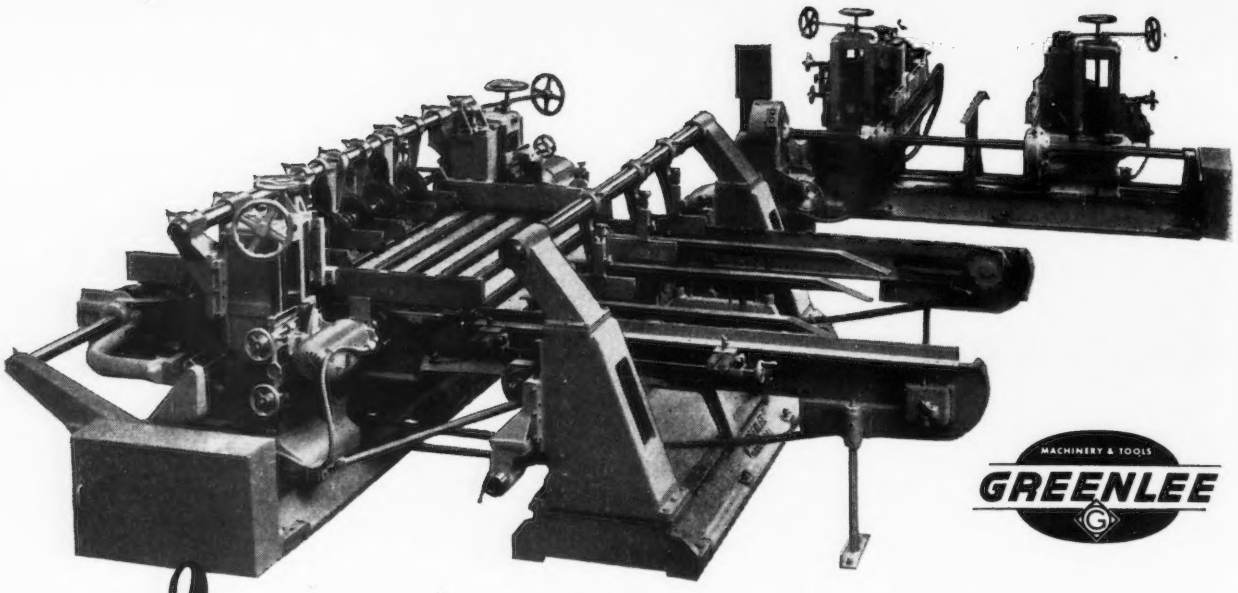

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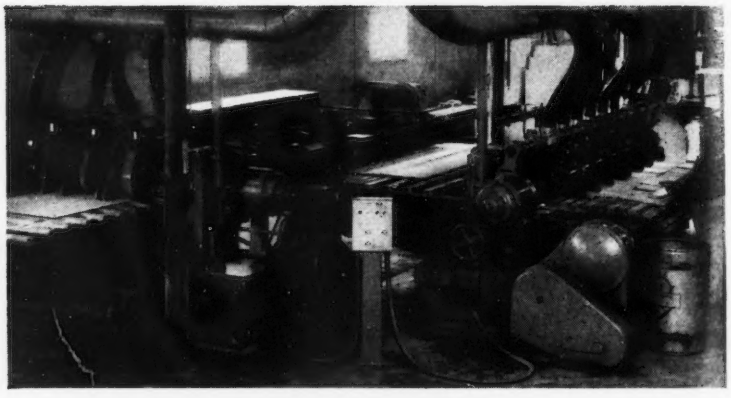
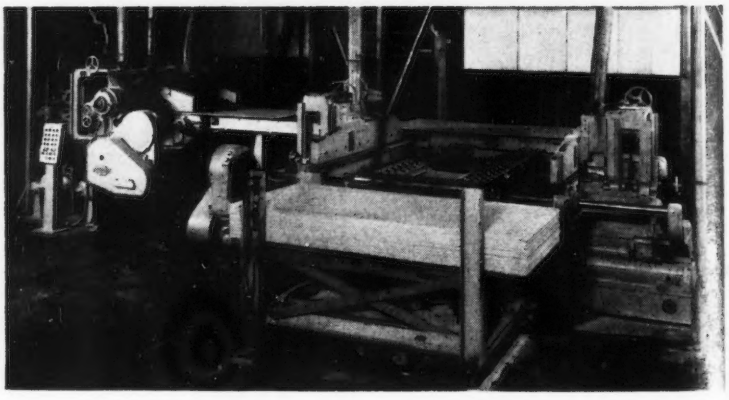


Slat-Bed Multiple Cut-Up Saws Cut Flat and Curved Particle Board. Equipped with overhead dado cutting units these Slat-Bed Machines with automatic transfer cut both curved and flat particle board with minimum changeover. Feed rates to 110 feet per minute. Operation is fully automatic and accuracy is assured.



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FPRS News-Digest

NEW FEATURES THIS MONTH

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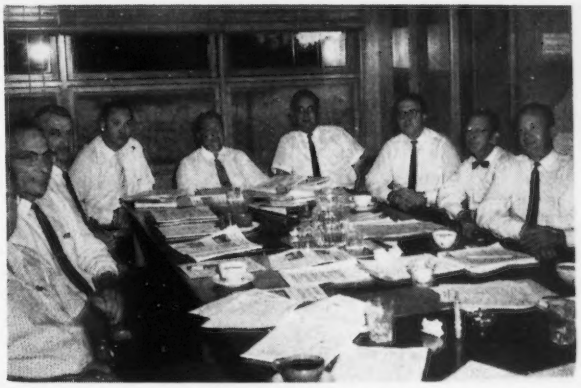
TELLERS COMMITTEE TALLIES BALLOTS on dues structure. Left to right: Miss Mary Sharkey, J. F. Lutz, K. E. Kimball, R. F. Blomquist, K. E. Huddleston, L. J. Fitzpatrick, Mrs. Janice Brunsell, and L. W. Crandall. Mrs. Brunsell and Miss Sharkey are on the National Office staff.



EXECUTIVE BOARD PLANS ACTION PROGRAM—In a special session July 25 and 26 at the National Office, the Executive Board considered ways and means to improve and increase the Society's services to the membership. Left to right: W. R. Smith, F. E. Dickinson, D. K. Saunders, J. L. Love, R. H. Berry, K. E. Huddleston, F. J. Rovsek, E. S. Harrar, A. F. Muschler.

Members Vote Dues Increase

The Tellers Committee reported on September 7 that the membership had ratified the increase in dues from $15.00 to $20.00 by a vote of 1059 to 247.

The dues increase was therefore approved and it went into effect immediately. By Executive Board action, the subscription price of the Journal was also raised to $20.00.

New members will now join for the period of 1 year from the date of joining, which will establish their anniversary date.

The Tellers Committee, which met at the National Office in Madison, consisted of: Chairman L. J. Fitzpatrick, R. F. Blomquist, K. E. Kimball, John Lutz and L. W. Crandall.

Carolinas—Chesapeake to Discuss Wood Finishes

The Carolinas-Chesapeake Section will hold its meeting November 10 and 11 in Raleigh, N.C. at the Hotel Carolina. The accent of the program is on wood finishes. Papers will cover present-day finishes, research on new finishes, and present day techniques used in pre-finishing plywood.

Technical Session I will be chairmaned by N. Clark Hatcher. Included in this discussion of wood finishing will be papers by J. A. Hager; B. G. Brand; and G. Maurice Hill.

Chairman of Technical Session II is Roy M. Carter. His group will hear presentations by R. C. Hadley; a representative of Darlington Veneer Company; and another speaker to be announced.

The Official Banquet, to be held Thursday evening, will feature Mr. Reid, vice president of the Duke Power Company, Charlotte, N.C. An additional feature of the program will be a tour of the North Carolina State College School of Forestry's newly dedicated Brandon P. Hodges Wood Products Laboratory. A finish application demonstration which utilizes equipment at the Wood Products Laboratory will be held to supplement one of the technical papers presented earlier in the session.

Second Industrial Adhesives Institute To Be Held On University of Wisconsin Campus

The Engineering Institutes of the University of Wisconsin and the U.S. Forest Products Laboratory, in cooperation with the Glues and Gluing Processes Division of the Forest Products Research Society will conduct the second symposium on Industrial Adhesives Applications to be held at the University's Wisconsin Center.

The program, which was initiated last year, consists of a 2-day session, October 25–26, which attracts industrialists and technologists from all over the country. Three general topics will be discussed by panels which include representatives of the various industries involved in the use of adhesives.

Industrial Adhesives

The Industrial Adhesives panel includes Sumner B. Twiss, Chrysler Corporation, Trenton, Mich., representing the automotive industry; Murry Funk, Marathon, a Division of American Can Co., Menasha, Wis., for the paper and packaging industry; Issac Sheppard, Jr., National Homes Corporation, Lafayette, Ind., from the housing industry; and James F. Eagan, J. E. Milligan & Company, Milwaukee, on the side of "Some Practical Applications of Adhesives on Leather, Fibers, and Fabrics."

Structural Adhesives

The panel on structural adhesives includes M. L. Selbo, U.S. Forest Products Laboratory, representing structural laminations; Robert E. Parkinson, U.S. Steel Corp., Monroeville, Pa., for curtain wall construction; Albert F. Martin, Minnesota Mining & Manufacturing Co., St. Paul, spokesman for metal assemblies; and Paul H. McCormack, National Starch and Chemical Corporation, Plainfield, N.J., on behalf of the particle board binding industry.

Equipment for Adhesive Binding

Discussing equipment used for adhesive binding is Karl Brunner, Black Brothers Company, Inc., Mendota, Ill., representing spreaders; R. A. Anderson, Williams, White & Company, Moline, Ill., for presses; and Herbert B. Reed, Raybond Electronics, Inc., Norwood, Mass., representing high frequency curing.

Kurt F. Wendt, Dean of the College of Engineering, University of Wisconsin, Madison, will welcome the participants. Richard F. Blomquist, USFPL, and Chairman of the Glues and Gluing Processes Division of FPRS will give an opening talk on "Adhesion From a Chemical-Physical Point of View."

"Con Edison" Employs Pressure-Creosoted Piles For Long-Term Economy!

With building costs rising higher and higher, long-term economy is practically a "must" these days. To help offset increasing costs . . . the Consolidated Edison Company, a major utility serving most of New York City and Westchester County, is installing close to 8,000 pressure-creosoted piles for the support of three new steel oil tanks at the East River generating station, East 14th Street, Manhattan. In addition to the tank foundations, piles are being driven for the support of concrete retaining walls for the tanks.

The installation of these pressure-creosoted piles (representing 210,000 gallons of creosote) is cited as *another* instance of how today's engineers are enabled to design permanent foundations in accordance with sound, modern, economical engineering practices.

If *you* are planning a project in which your building materials must be continually exposed to severe water or chemical conditions . . . consider pressure-creosoted piles!

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Upper Mississippi Valley	10	S. H. Wise
Mid-South	25	H. L. Russell
Northeast	50	R. C. Gill
Eastern Canadian	20	J. F. McCracken
Carolinas–Chesapeake	25	G. W. Smith
Southeastern	10	P. J. Bois
Pacific Northwest	50	Don Burnet
Inland Empire	10	J. P. Howe
Northern California	20	R. E. Black
Rocky Mountain	10	P. M. Opsal
Pacific Southwest	10	J. H. Hiller

Help your membership chairman meet his quota!

FPRS SECTION MEMBERSHIP GOALS

NATIONAL MEMBERSHIP CHAIRMAN Walton R. Smith (seated), and Vice-Chairman Robert Seidl take time out at the Fifth World Forestry Congress to discuss FPRS Membership goals of 300 new members by June '61. Exhibit arranged by T. S. Veazey, J. R. Ritchie, J. C. Killebrew.

Section Membership Goals Established for 1961

A membership goal of 300 new voting and associate members by June 1, 1961 has been announced by Walton R. Smith, Chairman of the FPRS National Membership Committee. Goals for the various Sections are shown in a boxed goal chart elsewhere in these pages.

Work of national and sectional membership officers is already showing results. From July 1 to September 30, 40 delinquent members paid their dues. In the same period, 31 new members joined the Society. The greatest surge of new memberships came in the latter part of this period, with 14 applications from September 15 to September 28. It is anticipated that the membership drives at Section meetings in October will establish a new membership record for October.

Both National Membership Chairman, Walton R. Smith, and Vice-Chairman, Robert Seidl, predict that the new membership provision, which enables a member to join for a forthcoming 12-month period, will make it attractive for new member solicitation in the Fall meetings.

L. J. Markwardt to Head AITC Review Board

The American Institute of Timber Construction has announced the formation of a Technical Review Board to serve as an appeal agency for participants in the Quality Control and Inspection Program and in an advisory capacity on all technical matters involving the recently formed AITC Inspection Program.

L. J. Markwardt, recently retired as assistant director of the U. S. Forest Products Laboratory will serve as chairman of the Technical Review Board. Mr. Markwardt is internationally known engineer and an authority on forest products.

In addition to Mr. Markwardt, the following industry representatives have been appointed to serve on an interim basis until the next annual meeting of the AITC which will take place in May, 1961: Robert E. Eby, Rilco Laminated Products; Maurice J. Rhude, Unit Structures, Inc., H. S. Sumrow, Timber Structures, Inc.; and N. L. Bailiff, Fluor Products Company, alternate. Thomas E. Brassell, Director of the AITC Inspection Bureau, will serve as secretary of the Technical Review Board.

Philippines, Syracuse Exchange Assistance

An assistance contract, designed to promote international cooperation and understanding, has been signed linking together the College of Forestry of The University of the Philippines and the New York State Forestry College at Syracuse. The program is sponsored and supported by the Philippine Republic and the International Cooperation Administration, an agency of the United States government.

Under the terms of the 3-year accord, the announcement added, the American Forestry College will furnish professional and technical assistance to the Philippine Forestry College.

It is expected that, during the 3-year contract, a total of 8 professional foresters from this country will go to the Philippines and, at the same time, 15 young faculty members of the College of Forestry of The University of the Philippines will come to the U. S. to familiarize themselves with American forestry techniques and methods.

Dr. Hardy L. Shirley, dean of the Syracuse College of Forestry, announced that 2 of the college's faculty members have been selected for 2-year assignments in the Philippines to help fulfill the terms of the newly-signed pact. They are Floyd E. Carlson, professor of forest extension, Division of Forest Extension and Public Relations; and John C. Sammi, professor of forest management, Department of Forest Management.

Named campus coordinator for the international project is Dr. C. E. Farnsworth, professor and chairman of the Department of Silviculture at the Syracuse Forestry College. Dr. Farnsworth recently returned from a technical assistance mission in the Philippines after being there almost 2 years.

FPL Men Give Papers at Tokyo Meetings

Dr. E. G. Locke, Director of the U. S. Forest Products Laboratory, Madison, will act as Chairman of the second meeting of the Food and Agriculture Organization working party on wood hydrolysis in Tokyo, October 10–15. Dr. Locke will also present 2 papers at the conference, entitled "World Activities in Chemical Conversion of Wood," and "Research at the Forest Products Laboratory on Chemical Conversion of Wood." The purpose of the wood hydrolysis meeting is to assess the present state of development of the most promising processes, outline the need for further research work, and plan future activities of the working party.

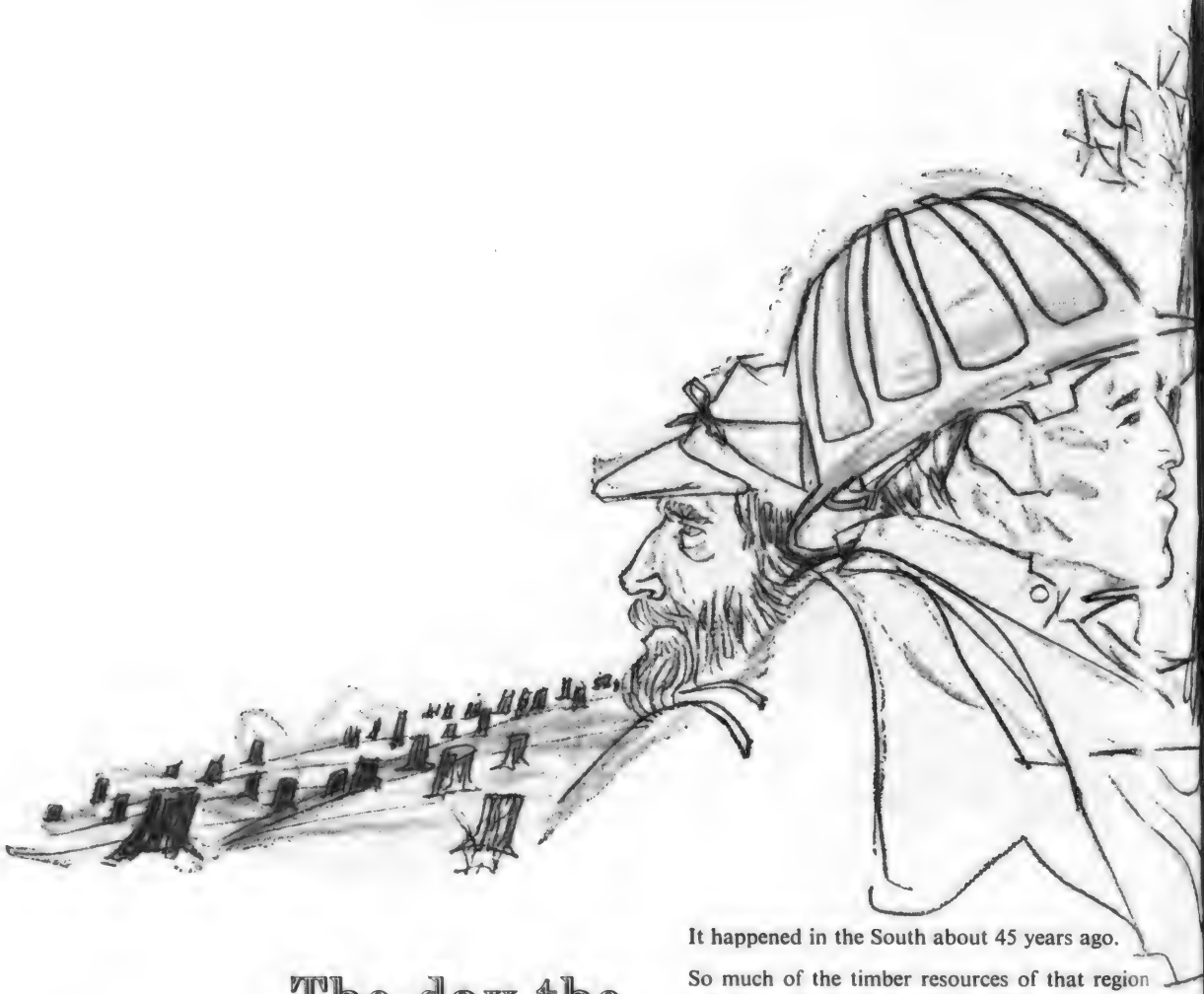
LOCKE

CHIDESTER

This conference is being held just prior to the FAO/ECAFE (Economic Commission for Asia and the Far East) Far East Conference on Pulp and Paper in Tokyo, October 17–31. G. H. Chidester, U.S. Forest Products Laboratory, Madison, is attending the meeting as a Consultant and Discussion Leader. He will present a paper on "Technical Progress Enhancing the Utilization of Fibrous Resources from Pulp and Paper."

Forest Genetics Lab Dedicated

The new laboratory at the Northern Institute of Forest Genetics, Rhinelander, Wis., was dedicated on September 30, announced M. B. Dickerman, Director of the U. S. Lake States Forest Experiment Station. The Institute, a field unit of the Lake States Station, was established near Rhinelander in 1957. It conducts research to improve the quality of planting stock of the northern conifer and hardwood species.



The day the lumbermen thought the forests were bare

It happened in the South about 45 years ago.

So much of the timber resources of that region had been exhausted that the lumbermen began to write off the South as a future source of lumber supply.

But trees grow.

In spite of uncontrolled fires and the lack of forestry programs, trees grow. And one day the timber owners noted that the forests had again thickened. They decided then that if forests could grow again after so many years of waste, misuse and natural disasters, a program of rigid policing would keep them productive indefinitely.

This was the start of scientific tree farming.

At Masonite, tree farming is insurance.

Millions of seedlings, planted every year, mea that growth will always equal cutting.

This is just one facet of Masonite's forestry ar reforestation program.

Trained foresters cruise Masonite forests daily—inspecting new growths, checking for disease, supervising harvesting, marking land boundaries, preventing fires, evaluating new land.

These foresters make sure that Masonite has a never-ending supply of wood to produce hardboards for the hundreds of present uses...and the hundreds of uses yet to come. These are liable to include anything that stands, lies flat, sits up, supports, contains, remains stationary, or moves by wheel, wind or water.

Masonite Corporation, Dept. FPJ-10, Box 777, Chicago 90, Ill.

MASONITE
CORPORATION

©Masonite Corporation—manufacturer of quality panel products for building and industry.

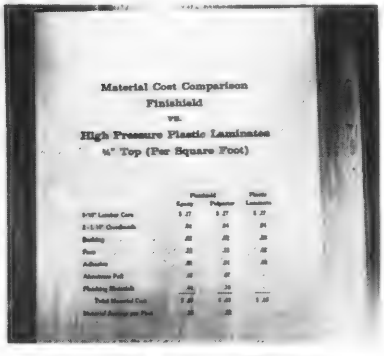
Finishield panel members are, left to right: Howard Gatewood, executive vice president, Fine Hardwoods Association; H. T. Austin, manager, Dri-Line Field Development, Polymer Industries; H. I. Watson, manager, Industrial Foil Sales, Aluminum Company of America; F. H. Thomas, director, Furniture Technical Service Department, The Sherwin-Williams Co., and Harold Sprunger, vice president, Dunbar Furniture Co.

Visitors to the National Office last summer were Dwight W. Benser and a group of Forestry students from Iowa State University at Ame Iowa. Back row, left to right: Norman Ferguson, Gerre Spencer, Jam Rash, William Barden, Jerry Leslie, and Phillip Summerfeld. Front ro left to right. Robert Ethingson, Instructor; D. W. Bensend; Richa Gains, and John Youker.

Finishield Found to Have Beauty and Durability

One of the panel meetings at the recent NAFM Fair which provoked considerable interest and comment was the one which formally introduced "Finishield," significant advance in furniture finishing.

In his introductory remarks, Howard Gatewood, pointed out that "Finishield" represents the end of a long search for a furniture finish which would offer all the beauty and authenticity of genuine hardwoods on all exposed surfaces yet possess the resistance to cigarette burns, abrasion and solvents claimed by substitute materials. He pointed out that "Finishield," now thoroughly tested in laboratories and furniture plants, fulfills all of these requirements and at a lower cost than laminated plastic substitutes.



Material Cost Comparison
Finishield
vs.
High Pressure Plastic Laminates
¼" Top (Per Square Foot)

Comparative costs of "Finishield" and plastic laminates.

"Finishield' plywood includes under the face veneer a sheet of Dri-Line aluminum foil, which dissipates heat and prevents surface damage. This foil has an indefinite shelf life and comes coated with a thermosetting adhesive that requires only heat and pressure from the bond. 'Finishield' exceeds the shear test requirements of CS-35-36 commercial standards for interior plywood.

The surface may be either polyester finish or epoxy finish. Tests proved that the polyester finish withstood an average of 998 cycles of the Taber Abraser before getting down to the wood and the epoxy finish withstood an average of 600 cycles. The high pressure plastic laminate control withstood an average of 618 cycles.

Solvent resistance was determined by subjecting finished panels to direct contact with 100 proof alcohol for a six-hour period. Both of the finishes satisfactorily passed the requirements of solvent resistance

Battelle Institute Begins Contract Research Series

The first in a series of illustrated statements on contract research for industry has been published recently by Battelle Memorial Institute, Columbus, Ohio. Titled "Procedures of Contract Research for Industry", this first statement serves as a point of departure for the series, which is oriented toward executives in industry who have varying degrees of decision-making responsibility for research and development programs.

"Procedures of Contract Research for Industry" describes in a step-by-step manner the relationship existing between the client and the research institute, beginning with the initial meeting of the 2 parties and progressing beyond the successful completion of a specific project. Phases of this relationship discussed include the preliminary conferences between the client and the research institute that precede the initiation of a research project; conferences among institute specialists to define the research objective and evaluate possible approaches; the contractual agreement between the research and the client; actual conduct of the research; reports to the client while the research is in progress; and the presentation of final results, as well as follow-up services provided by the institute.

Copies of the first brochure are available from: Publications Office, Battelle Memorial Institute, 505 King Avenue, Columbus 1, Ohio.

Wood Conversion Grant Given Minnesota Student

George M. Blake, a graduate student the University of Minnesota School Forestry, has been awarded the Wo Conversion Foundation Graduate Resear Fellowship for 1960–61. The announc ment was made jointly by Dr. T. Schant Hansen, professor emeritus of the Scho of Forestry, and D. M. Pattie, President Wood Conversion Company.

The funds provided for this project will be used to support graduate research in the field of forest-tree genetics and tree improvement. The long-range objective of this research is to improve the quality of aspen, which presently makes up almost 40% of all pulpwood produced in Minnesota. The specific objective of the research carried on by Blake will be to develop some of the basic principles of aspen genetics needed for a better understanding of how heredity and environment influence the yield and quality of aspen in northeastern Minnesota.

Education Programs Beneficial to Forestry

Forest owners in the U. S. have reap d large benefits from public and indust financed education programs, according to a report by Frank H. Kaufert, director, U versity of Minnesota School of Forestry. He said these programs have resulted in m h better forest fire prevention and contro the first need in applied forest manageme Other management benefits, especially n small woodlands, may be less evident but are still important.

Education and service programs affec l million U. S. farmers and other land ow ers, Kaufert said. The most important p lic programs include Extension Fores Private Forest Management Service, Coop ative Fire Control, Soil Conservation Se ice, Agricultural Conservation Progra Tennessee Valley Authority, Vocational A riculture Education and 4-H programs.

Borden Adhesive Report

Availability of an adhesive report entitled News In Glues" from The Borden Chemi-al Company, has been announced by R. J. .odge, general manager, Resins & Chemi-als Department. The report consists of 11 general and technical papers covering new levelopments in adhesive technology as re-ated to the manufacture of wood prod-cts. Much of the information is being ade available to the wood industry for e first time. For a free copy of "News In lues" write Department H, The Borden hemical Company, 350 Madison Avenue, ew York 17, N.Y.

NWPMA Issues

The National Wooden Pallet Manufac-rers Association announces the publica-ion of an Inspection Procedure for use by customers in determining whether pallets received are made in accordance with the specifications of what was ordered. It is intended to be used as a guide in arriving at logical inspections of wooden pallets.

The Inspection Procedure includes information on place of inspection, time of inspection, scope of inspection, inspection personnel, and rejection. Valuable suggestions and precise rules are provided by it as a yardstick for customers to follow. The Inspection Procedure has been adopted as an industry standards by NWPMA, and its members.

Special Study Shows Arizona's Potential

Arizona's 17,000,000 acres of commercial and non-commercial timberland represents one of the greatest untapped industrial potentials in the Southwest, according to the finding of a special forest products study made by the Arizona Development Board and the Forestry Division of Arizona State College. Though lumbering now accounts for Arizona's fourth largest industrial payroll and contributes some $30 million to the overall economy of the state, the study report concludes that the surface has barely been scratched. It shows that, despite its wealth of raw material, the state has virtually no so-called "secondary" wood products industries.

The report, co-ordinated by ASC's Dr. Charles O. Minor and Edward P. Enders, Industrial Director of the Arizona Development Board, with the help of other state and federal forestry experts, points out that at least a dozen other wood industries could be supported without depleting Arizona's forest resources.

BRI to Discuss Fastening Devices

Instances of failure of curtain walls due improper use of fastening devices, pled with the wide variety of fastening vices currently on the market have pin-inted the need for some expert analysis of subject. The Building Research Institute therefore listed "Fasteners for Industrial rtain Walls" as one of the 4 major topics its forthcoming 1960 Fall Conferences, v. 15–17, Shoreham Hotel, Washington,

New Standard on Fir Doors

Copies of a new, enlarged edition of Commercial Standard CS73–51, Old Growth Douglas Fir, Sitka Spruce, and Western Hemlock Doors, have just been circulated for industry consideration by the Commodity Standards Division, Office of Technical Services, Business and Defense Services Administration, U. S. Department of Commerce.

Copies may be obtained, as long as the supply lasts, upon request to the Commodity Standards Division, U. S. Department of Commerce, Washington 25, D. C. (DUdley 6–1207). Ask for *tentative standard TS–5427A.*

Wood Waste Brochure

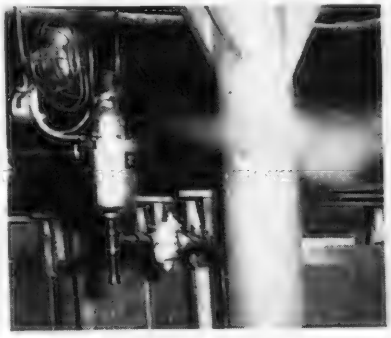
A new brochure released by the American Pulverizer Company, St. Louis, shows the complete line of American Swing Hammer Hogs and Shredders and also shows plant operations where furniture and woodworking plants are converting wood waste to profitable use with this equipment. Various models of hogs and shredders are pictured and specifications are listed for each model.

For a copy of this new brochure write American Pulverizer Company, 1249 Macklind Avenue, St. Louis 10, Missouri. Request Brochure No. H–60.

To the Executive Concerned With Improving Profits

How would you like an investment that returns the principal the first year and pays 100% each successive year?

If your plant is in an area where outside temperature in winter falls well below freezing, you can make such an investment.



The investment?

Armstrong Humidification for your plant.

Your production people can tell you what dry air in the plant during the heating season means in terms of stock losses, gluing problems, and excessive repairs. Scores of users have told us that the cost of Armstrong Humidification is *no more than the cost of one season's losses resulting from dry air.*

You can get a more accurate indication of the investment required by asking us to have an Armstrong Representative to make a humidification survey of your plant. Do it, today. We think you'll be pleasantly surprised at what a small investment is necessary to start earning big returns.

ARMSTRONG STEAM HUMIDIFIERS

Manufactured and Guaranteed by the Makers of Armstrong Steam Traps

ARMSTRONG MACHINE WORKS

9562 Maple Street • Three Rivers, Michigan

PARTNERS IN PROGRESS AND LEADERSHIP . . .

Elm corner post is sanded on pneumatic drum sander using 3/0 (120J) RESINIZED GARNET Cloth Doubleflex.

This beautiful dresser and mirror are representative of the fine work turned out by Imperial Furniture Company, Grand Rapids, Michigan. The pieces are in butternut and elm, with walnut inlay.

NICE WORK and you get it every time when you combine the skill of the craftsman with the quality of BEAR Brand coated abrasives. Service, too . . . through the facilities of "Abrasive Tech." Just call your nearest Behr-Manning representative, or write Dept. FP-10, BEHR-MANNING CO., Troy, N. Y., a division of Norton Company.

BEAR BRAND Abrasives

Like Great Rivers...

RELIABLE SOURCES GIVE A CONSTANT DEPENDABLE FLOW OF RAW MATERIALS

AMERICAN-MARIETTA buys raw materials from the most reliable sources in order to procure greatest value from highly specialized competing suppliers. Included in this value are best performance, most dependable service, and latest technological improvements.

American-Marietta is not inhibited by large financial investments in sources of basic raw materials which stifle the scope and progress of research for new and better products.

Rather, we invest substantially in research facilities, programs, and services with sincere faith that this will return the greatest benefit to our customers–future profitable growth.

AMERICAN-MARIETTA COMPANY

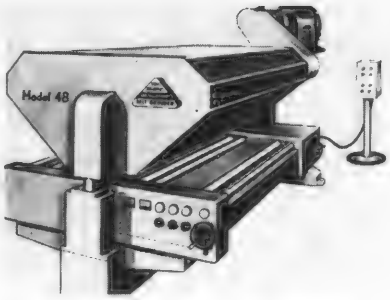
ADHESIVE, RESIN & CHEMICAL DIVISION

SEATTLE, WASHINGTON • NEWARK, OHIO

A-M

ADHESIVES & RESINS FOR PLYWOOD, WET STRENGTH PAPER, CORRUGATED CONTAINERS, PULP MOLDINGS, COMPOSITION BOARDS, MINERAL WOOL, FOUNDRY CORES & SHELL MOLDS

Our Research Today for Your Progress Tomorrow

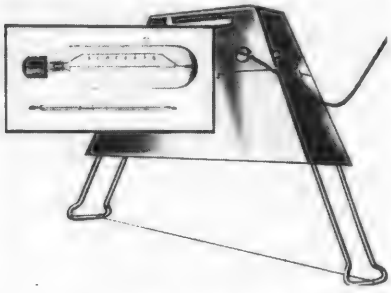


Faster Sanding Machines

Faster sanding through positive controlled oscillation of the abrasive belt plus extreme accuracy resulting from rigid construction that prevents the abrasive belt from riding over surface irregularities are two of the outstanding features claimed for the new Tri-Matic Oscillating Abrasive Belt Machines recently developed by Sales Service Mfg. Co., St. Paul, Minnesota.

The new series in 24-, 36 and 48-inch sizes differs from the smaller Tri-Matic machines which are knee type, in having a solid base and a workhead adjustable from 0 to 6-inch work opening with pinch roll infeed and outfeed instead of a conveyor. The machine may be used alone, incorporated in a production line and multiple head installation may be arranged for continuous in-line operation.

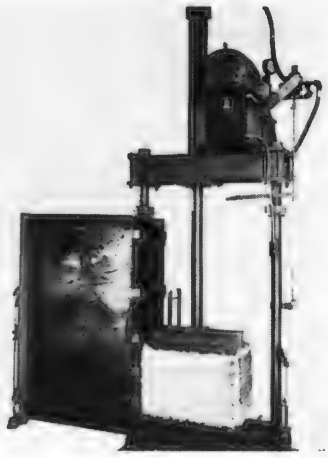
For complete information on the new series of Tri-Matic Oscillating Belt Machines write to Sales Service Mfg. Co., Dept.—, 2363 University Ave., St. Paul 14, Minn.



Guide Line Light Has Long Life

A new model Guide Line Light which projects unusually sharp shadow lines to guide cutting ,marking or assembling operations has been announced by Miss Thelma L. Watson, executive vice-president of Carter Products Company, Inc., Grand Rapids, Michigan.

To be known as the Q–15 Guide Line Light, the new unit features a recently developed 1500-watt bulb only ⅜″ in diameter which will turn approximately 2000 hours without slightest loss of efficiency, according to the manufacturer. A special reflector, designed for use with the new bulb, increases the lumen output to deliver unusually clear marking lines in a pattern 18″ to 22″ wide with a useful length of 12′ to 24′, the report continues. The unit can project any desired number of parallel straight shadow lines, square or rectangles, or can project a single white line for use on dark materials.



Wood Shavings Balers

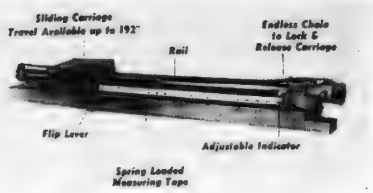
Improved version of consolidated's famous Double Chamber, Wood Shavings Balers incorporates high speeds and pressure for maximum production of dense, compact bales. Utilizing the double chamber feature that allows simultaneous loading and compressing, these self-contained, compact Balers assure efficient, and profitable baling of wood waste. Write Consolidated Baling Machine Company, Dept. FPR, 195–197 Sixth St., Brooklyn 15, New York for complete descriptive literature.

Tree Crusher

The wooded areas being cleared have been interfering with electronics equipment being tested by the National Aviation Facilities Experimental Center, Atlantic City. The specialized machine—called a Tree Crusher by its manufacturer, R. G. LeTourneau, Inc.—fells the trees and compacts the debris into a mat to prevent erosion at a rate of 3 acres per hour.

Polymer Completes Plant Expansion

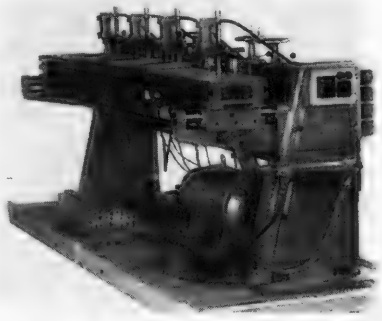
Polymer Industries, Inc., producer of industrial adhesives and textile specialty polymers, on September 12 dedicated its recently-completed milion-dollar plant expansion. Polymer's founders, F. C. Campins, president, H. L. Kane, vice-president and technical director, Moses Konigsberg, vice president, and J. W. Ogletree, vice-president, are all highly-skilled polymer scientists who combined their technology with their imagination and created in 1946 a new concept of "Performance Engineering" to begin this nationally-known industry.



Slide-Loc Saw Guide

The Slide-Loc Saw Gauge is a new invention which reduces to one-half the time needed to cut varying lengths of wood, metal, plastics and glass, insuring accuracy to a degree never before possible. The Gauge consists of an adjustable measuring mechanism that is set instantly and accurately to any desired length up to 192 inches. A special feature is that the operator never moves from his position at the saw in order to set the gauge.

When the board is pushed against the flip lever on the sliding carriage, the exact length to be cut off is pointed out on the measuring tape by an indicator. A light pull on the endless chain locks the carriage rigidly and accurately to the rail so that one cut or thousands of cuts may be made with great accuracy and without any strain on the measuring tape.



New Mortising Machine

Haller, Inc. announces a new machine in its line of single and multi head mortisers, the 3 ASP–S2, completely automatic and air operated, equipped with 4 high frequency mortising heads and clamping units with provisions for installation of additional mortising heads and clamps.

The 3 ASP–S2 produces clean, splinter free mortises with unrivaled precision and neatness. Utilizing an "Oscillating-Scooping" motion at high speed, this machine makes rectangular, dovetail, and elongated holes and special mortises with square corners and nearly flat bottoms for good gluing fits.

Chemical Corps Combine

The Timber Products Chemical Company and Sonford Chemical Company have combined to form the Sonford Products Corporation, it was announced recently. The principals of the corporation are Howard Olson, who heads the Northern Division with offices in Minneapolis, and Troy Buford, who heads the Southern Division Jackson, Missisippi. The Sonford Products Corporation, which is engaged in the wood preservative business, is a distributor of the PENTA products produced by Reichhold Chemicals, Inc.

OUR FOUR-POINT PROGRAM

For best utilization of America's timberlands

1. **Good management of our forests—by the most advanced tree-farming methods.**
2. **Products research to utilize to the fullest the timber we cut, so that nothing goes to waste.**
3. **Modern marketing and sales management to balance product demand against materials supply.**
4. **Consumer-oriented development of products to make sure that every product is planned to fill a known consumer need.**

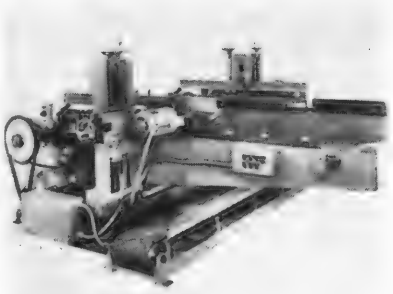
A simple program—simply stated—but it requires vast investments in skilled manpower, lumbering facilities, forest management, research and development laboratories, and modern plants. And—to get the most effective distribution—widespread modern warehousing and sales operation to be sure that our forest products reach markets in every part of the country.

United States Plywood—40 years old, in 1959—is in business for the future as well as the present.

That is why you will find throughout our organization a dedication to those efforts which will make for the BEST UTILIZATION OF AMERICA'S TIMBERLANDS.

United States Plywood

55 West 44th Street, New York 36, New York



New Woodworking Machine

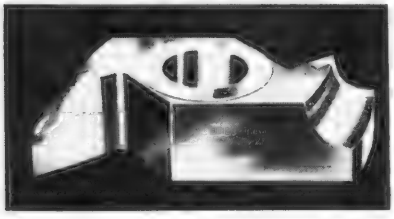
Latest addition to the Mereen–Johnson line of woodworking machinery is a new double-end trimmer-printer-waxer with refuse belt. The first of these machines has been installed at Reedsport, Oregon.

The new machine accommodates studs of any desired lengths between 6 and 10 feet through adjustment of a movable beam. A refuse belt below the two saws carries off scrap continuously.

All-Wood Warehouse Praised

The Crossett Lumber Co., Crossett, Ark., has constructed an all-wood warehouse that serves as an attractive, low-cost advertisement for its product, Engineering News Record reports. The structure has a capacity of four million board feet of rough lumber and supports 53 tons of rail crane spanning its 101-foot-wide interior.

The cost: $5.65 per square foot—"a pretty low figure considering the framing design provision for a gantry crane," according to ENR. Including the ten-ton capacity crane, trolley, bridge, rails and motors, the cost figures out to $9.81 per square foot. (Lumber Letter, July 15).



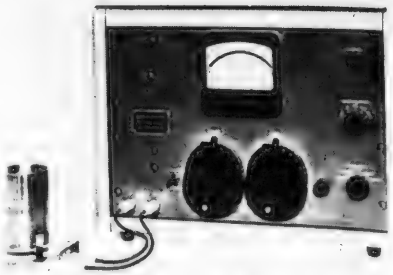
Tru-Form Cutters

The Boice–Crane Company, Toledo, Ohio announces a new and second line of TRU-FORM Cutters with involute relief featuring carbide tips which deliver up to ten times the productive life of ordinary cutters when working plywood and resin-bonded chipboards. They employ a new sintered titanium carbide which has the property of easy machinability in the soft state, and hardening properties closely comparable to tungsten carbide or cast cobalt alloy tool compoents. Write the Boice–Crane Co., 929 Central Ave., Toledo 6, Ohio for more information.

Nottmeyer Veneer Taper

Wilco Machine Works, Inc. announces availability of the Nottmeyer Veneer Taper, a machine described as being so carefully designed that it offers a new level of efficiency in veneer manufacturing. The Nottmeyer uses recently developed Swedish tapes that are smaller, thinner, yet many times stronger than standard tapes and cost from 1/3 to 1/2 less. This greater strength and smaller size make possible improved taping accuracy at high speed and low cost.

Unlike most tapers, the Nottmeyer does not push, pull or draw the veneers together. Two canted rollers simultaneously and automatically feed the veneers and bring them together to form high fidelity joints—whether veneers are straight, buckled or brittle. Each of these rollers compensates for thickness variations in the veneers as they are fed and taped. The only adjustment ever necessary for thickness variations is on a switching lever that controls two thickness ranges.



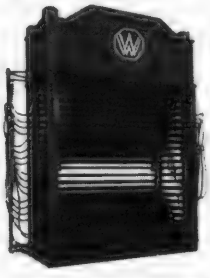
New Moisture Analyzer

A high speed general purpose industri moisture analyzer, Model HFE-4E, designe especially for process or quality contr systems, has just been announced by th Boonton Polytechnic Company, Inc. Employ ing a new method of moisture determin tion by means of radio frequency pow absorption, the polytechnic moisture a alyzer offers laboratory accuracy under fa tory conditions. For further informatio contact Boonton Polytechnic Company, In Dept. 115, P.O. Box 125, Boonton, N.J

FORECAST:

New markets for plywood - with Williams-White presses leading the way!

For every human being in the world more than 10 square feet of plywood are in daily use. As research and new techniques open fresh markets, and as America continues to grow, consumption will rise to even richer levels. What will be YOUR share of the new plywood markets? The key is reliable, low-cost production. Williams-White hot plate presses offer precision control plus great strength and dependability to give you maximum production every day. To keep competitive.....keep in touch with Williams-White.



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Whatever the product—
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METAL...WOOD...PLASTIC
or PAPER—there's a
Lilly coating made to fill
the finishing requirements
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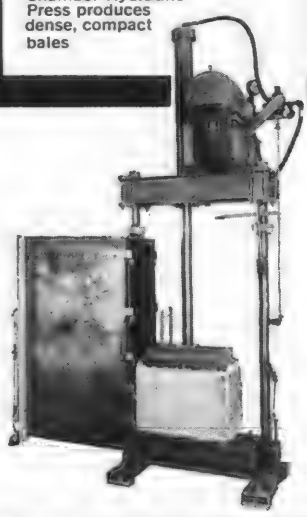
PROFIT FROM WOOD WASTE with CONSOLIDATED BALERS

Duplex Double Chamber Hydraulic Press produces dense, compact bales



Shavings, fibers, wood flour and chips can be turned into a steady source of considerable profit with a modern, low-cost Consolidated hydraulic baling press.

The Consolidated Duplex reduces high-speed baling to practically a push-button operation with complete safety, economy and efficiency, lowest operating costs.

Dense, compact bales sell more easily to poultry and dairy farmers, paper mills, hardboard, particle board and molded products manufacturers, nurserymen, florists, etc.

There is a Consolidated all-steel hydraulic baling press to meet your every need — write for free catalog today.

- **Loads and compresses simultaneously**
- **Over 35 dense, compact bales per hour**
- **Lowest shipping and handling costs**
- **Lowest operating costs**

Consult Consolidated on all hydraulic equipment problems — no obligation

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BALING MACHINE COMPANY
195–197 Sixth Street
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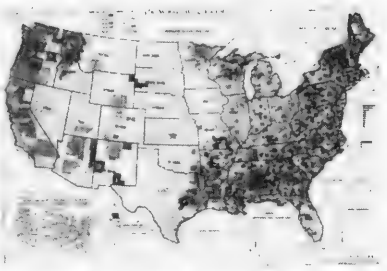


Information about woodcutting in every county in the U. S. is recorded on large 6-color map produced by Market Research Department of Oregon Saw Chain Division, Omark Industries, Inc.

Woodcutting Survey Tells Marketing Information

A comprehensive survey of the Woodcutting Industry based on some 14,000 questionnaires and 300 personal interviews has been recently completed by market research personnel from Oregon Saw Chain Division, Omark Industries, Inc., Portland, Oregon.

The survey, thought to be the largest ever undertaken by a private firm in the woodcutting field, uncovered new data about the relative strengths of regional markets for timber harvesting equipment.

For example, the results pointed out that in 1958 about 77% of the cutting chain and 78% of the chain saws were sold *east* of the Rockies, indicative of a strong, but frequently overlooked, eastern market for woodcutting equipment. The survey showed that sales of power saws and saw chains were often higher in the so-called farming and industrial states than in those more generally associated with logging and pulpwood cutting.

The Omark survey also produced a variety of miscellaneous information. For example, the "Two-Saw Owner" is becoming increasingly prevalent. Forty-four percent of those surveyed owned 2 or more chain saws in 1958. Sixty-six percent stated they had bought a saw within the last year, 85% within the last two years.

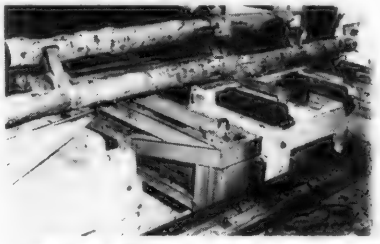
The survey, which broke down its information county-by-county in most cases, also showed that there are 69 counties of prime importance to the U. S. Woodcutting industry. In each of these 69 counties there are over 2,000 persons working in timber and allied industries. Georgia has 12 of these counties, and Oregon and Washington are next in line with seven counties apiece. However, some of these counties, like Los Angeles County in California have everybody in "allied industries" and few, if any, in direct timber harvesting.

For additional information about this survey, write to advertising department, Omark Industries, Inc., 9701 S. E. McLoughlin Blvd., Portland 22, Oregon.

Loggers to Discuss Forest Industries

The annual fall conference of the Utilization Division of the Northeastern Loggers Association, Inc., will be held at Harrisburg, Pa., Nov. 21 and 22, 1960, according to an announcement by Fred C. Simmons of the Northeastern Forest Experiment Station, Upper Darby, Pa., Chairman of the Division. Co-sponsors of the conference will be the Pennsylvania Departments of Commerce, and of Forests and Waters.

The object of the conference will be to point out specific opportunities for new or expanded forest industries in the Northeast. Special invitations to attend are being sent to representatives of the many regional and local industrial development organizations in the 12 northeastern states. Members of the Loggers Association, and an other who are interested, are also invited to attend. Registration blanks and further information can be secured from Fran Schrey III, Forest Utilization Adviso Penna, Department of Forest and Water Harrisburg, Pa.



Preston bar nigger and log stop-loac installation at the A. J. Murphy Lumber C Latchford, Ontario.

Hydraulic Log Handlers

The Super Swede Log Stop-Loader a the Super Swede Bar Nigger, built Preston Woodworking Machinery Co pany, Ltd., form a hydraulically actuat deck installation that steps up productio without increasing steam capacity.

Twin hydraulic cylinders permit ind pendent fingertip control of both horizont and vertical movement of the bar nigg The standard bar assembly has a 27-inch vertical stroke while the heavy-duty model has a 36 inch stroke. This provides a longer backward reach on the deck for better handling of rough and crooked logs the hydraulic stop-loader, available in any specified length, delivers one log at a time as required by the sawyer. Its arms are taper—keyed to a heavy-duty 2–15/16-inch shaft and mounted on four babbitt bearings. The unit is activated by a hydraulic cylinder connected to the hydraulic system by two high-pressure hoses. Quick disconnects are supplied with the hoses. To operate as a double-cut head rig, the stop arms can be extended to bridge a live-roll deck.

Bulletins are available from the Pr ton Woodworking Machinery Compan Ltd., Preston, Ontario, and the Calvert-Preston Machine Services, Ltd., Bori Oregon.

Wooden Pallet Group to Hold Conference

The National Wooden Pallet Manut tures. Association announces a conferer and a clinic to be held during Novemb

The 4th Annual Wooden Pallet Manut turing and Promotion Clinic will be h November 14–15, at the U.S. Forest Pr ucts Laboratory in Madison. This progr will cover such subjects as effective m chandising of wooden pallets, basic qual cation for pallet sales, and needs for pal research.

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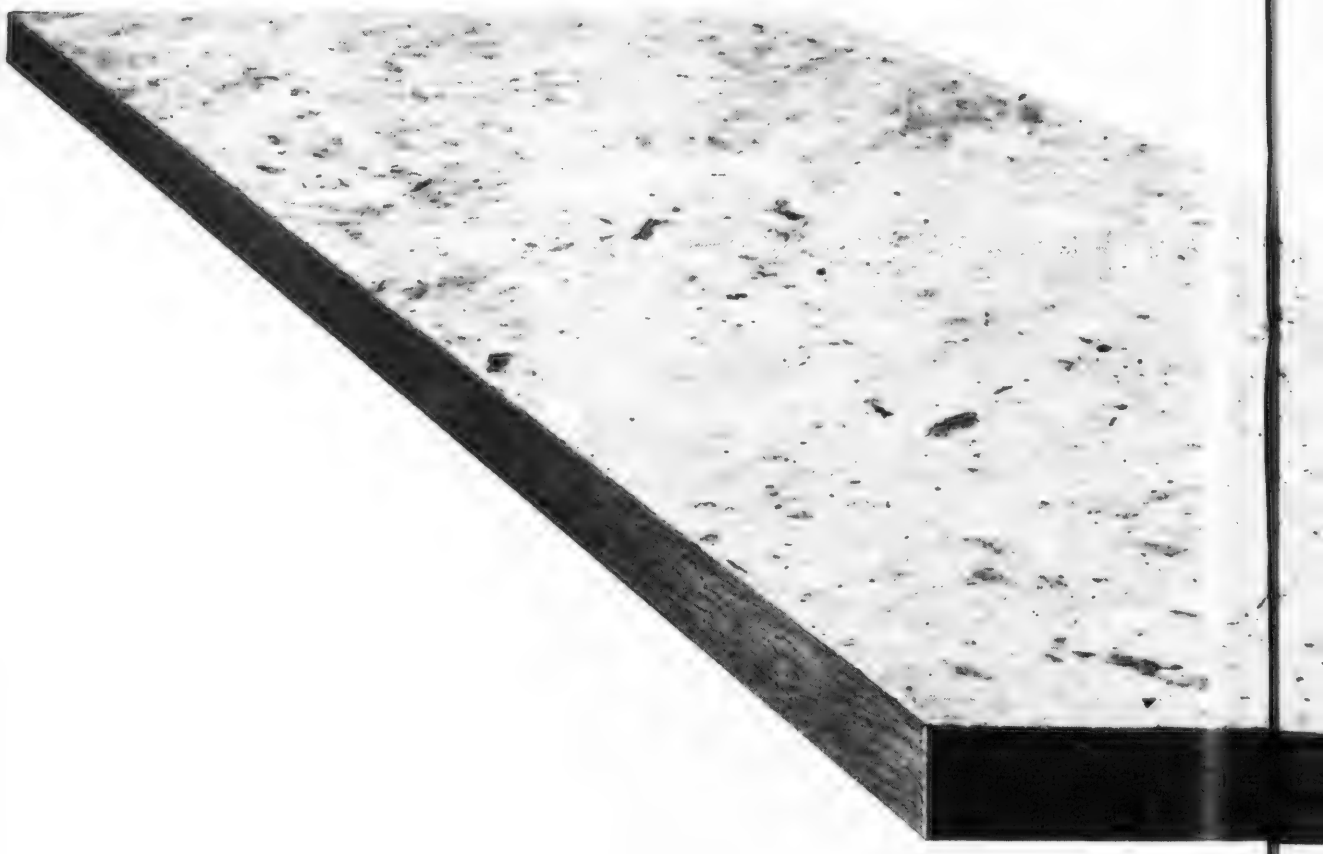
WHEN YOU'RE IN THE WOODS



ON UREA RESINS

CALL BORDEN FOR HELP!

It just isn't easy to find a urea that is exactly right for your particle board operation. But it can be done ... and most profitably for you ... by calling in Borden.

Borden knows woods . . . from seedling through every step of manufacture. Our technically trained wood technologists analyze your needs, make test runs, set up manufacturing and testing procedures. Working with Borden research and development laboratories, they *tailor* a urea resin to give you top product quality *and* top production efficiency.

Borden urea resins are made to highest quality standards. They provide high internal bond, fast and uniform cure, excellent MOR and MOE, good screw-holding qualities, and long storage life. Strategically located plants in Bainbridge, N. Y., Demopolis, Ala., Fayetteville, N. C., and Browntown, Wis., assure fast delivery.

Ask your Borden' technical representative about urea resins for particle board. Or, write The Borden Chemical Company, Resins and Chemicals Dept. F.P.-100, 350 Madison Avenue, New York 17, N. Y.

THE **BORDEN CHEMICAL** COMPANY

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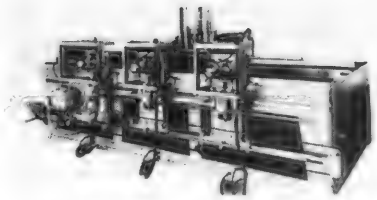
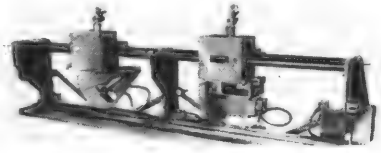


Kvalheim Introduces Two Machines

Kvalheim Machinery Company of Petaluma, California has added another machine to their line of door equipment. It's called the KVAL No. 880 Automatic—and it is automatic.

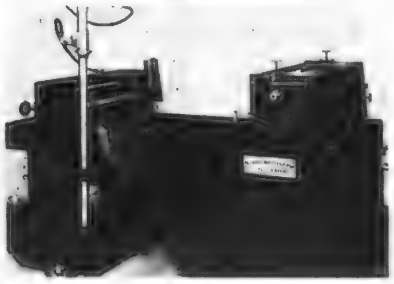
The doors are merely slid against a limit switch stop and all the machining operations for hinges and lock are performed in 12 seconds. This machine may also be used directly behind a KVAL double head Edging Machine (model 550). By arranging a layout of this type, the doors are sized with correct bevel and then conveyed onto the KVAL 880 Automatic for hinge and lock machining.



KVAL has also developed recently a saw for trim cutting requirements, designated as the KVAL No. 1040.

Two blades come down simultaneously to cut trim material and the like to exact length and correct mitre. Each blade may be rotated from 90° to 45°. By this system it is possible to cut trim with two 45° ends or one end 45° and the other 90° and so forth.

Top Efficiency Grainer



A new Dubois combination graining machine and roller coater sealer is making a saving of 50 per cent in time and labor at the Velpin, Ind. plant of the United Mfg. Co., John Schnaus, President of the desk manufacturing company, has announced. Production is so great that the machine is operating only about one half of the time, he said. The new Dubois Model PS is manuafctured by the Dubois Machine Co., Jasper, Ind. It is built in two sizes: with 26-inch printer and sealer; and 36-inch rolls.

Although the machine is not tied in with a conveyor line at the United Mfg. Co. plant, it is designed to be used with a completely automatic finishing line, teaming up with base and finish coaters and drying ovens.

U. S. Plywood Holds to 80 Percent Production

United States Plywood Corporation which led the industry in cutting fir plywood production 20 percent in August, has announced long range plans that will maintain production at the 80 percent level.

Gene C. Brewer, company president, said that operation of West Coast fir facilities on a four-day week basis had proved "effective but not practical for the long pull."

"Consequently," he said, "the plants are being put back on a five-day week, effective September 26, and our curtailed production will be achieved through necessary manpower adjustments or elimination of shifts, dependent on the most efficient way each plant can be operated at the 80 per cent level."

Mr. Brewer said that the company's plans for long range curtailment of production are in recognition of the need for producing efficiently at a curtailed production rate that is adjusted to the demands of the market.

St. Regis Announces Scholarships

St. Regis Paper Company announces the award of its undergraduate scholarship in forestry in the northeastern United States for the academic year 1960-61 to John A. Martin, a forestry student at the State University of New York, at Syracuse, New York.

Mr. Martin was chosen by a committee consisting of Hamilton K. Pyles, regional forester, U.S. Forest Service, Upper Darby, Pennsylvania; Dr. Ralph Marquis, director, Northeast Forest Experiment Station; and Paul M. Dunn, St. Regis Director of Forestry.

Mr. Martin, a native of Albany, New York, is a graduate of the Milne School in Albany. He has been active in forestry research and in extra curricular organizations in the field of forestry at the College of Forestry.

St. Regis annually awards five undergraduate scholarships in forestry—three in the South and one each in the Northeast and Northwest. The Northwest award was made to James C. Space, a junior at the College of Forestry, University of Idaho, and the Southern awards are to be announced in the near future.

Booklet by Weyerhaeuser

A comprehensive new 16-page 4-color booklet, entitled "A Catalog and Guide for Builders and Architects", provides specific product data and detailed working and application instructions for Weyerhaeuser hardboards. It presents specifications and color photos of the entire line of exterior and interior hardboard types for construction uses and illustrates many decorating and building ideas.

A copy of the new "Catalog and Guide for Builders and Architects" is available from distributors and dealers of Weyerhaeuser hardboards or directly from Silvatek Division, Weyerhaeuser Company, Tacoma, Washington.

Redco's New Brochure

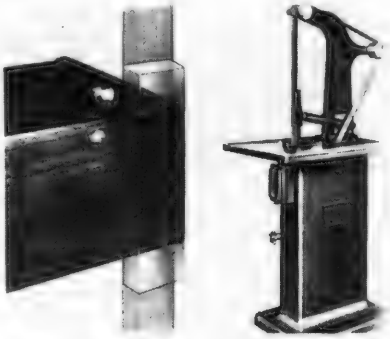
A new 4-page, 2-color brochure recently released by Republic Electric & Development Co., Seattle, describes the firm's DC electric veneer lathe drive system, now in use at leading veneer mills in the plywood producing centers of the nation. The brochure illustrates and describes how the Redco DC lathe drive cuts faster, while maintaining steady speed with better control. The system has more than ample torque to peel the largest diameter log the lathe can swing, and maintains top sheet speed down to small core diameter.

For a copy of this informative brochure, write Republic Electric & Development Co., 2627 Western Avenue Seattle 1, Washington.

ASTM Symposium On Sandwich Construction

The aircraft and building construction industries are making widespread use of the structural sandwich panel, made possible through simultaneous developments in the structural adhesive and the light-weight core material fields. Considerable savings in weight, assembly time, and costs have been realized, with the added advantages of improved appearance and smoothness. This Symposium, while not a complete study of durability and service experience, adds to the rather meagre published information. It is hoped that this publication will answer some questions concerning service performance in this relatively new area.

Copies of this book may be obtained from ASTM Headquarters, 1916 Race St. Philadelphia 3, Pa. at $3.00 each.



Narrow belt with backup plate, (left) sands in sharp corners to knock off dovetail stubs; (right), Ekstrom, Carlson No. 123 Variety Belt Sander.

Variety Belt Sander

Several wood working plants have solved problems such as sanding off the overextension of the dovetail joints on drawers that have the front extending beyond the drawer sides by using the Elkstrom, Carlson No. 123 Variety Belt Sander. The narrow belt, together with its backup plate allows the dovetail extension to be sanded perfectly smooth right into the sharp corner as illustrated. A perfect fit results. The belt does an excellent job on all applications where it is necessary to sand sharp corners such as this. For detailed description of the machine write to: Ekstrom, Carlson & Co. 1400 Railroad Avenue, Rockford, Illinois

NAMES in the NEWS

Stanley A. Clarke, Chief of the Division of Forest Products, C.S.I.R.O., has recently retired from active duty. He has made a major contribution to the fuller and better utilization of timber and wood products, and has established a reputation both in Australia and overseas as an authority on such widely different major activities as those of the pulp and paper, fibre board and particle board industries.

C. B. Wilcox has joined the Wood Preserving Division of Koppers Company, Inc., as Manager, Building Code Department. **Douglas Grymes,** vice president and general manager of the Division, made the announcement.

Appointment of **Bradford E. Bailey** as international project manager of the central engineering department of The Borden Chemical Company, has been announced by **W. R. Moffitt,** senior vice president. Mr. Bailey will be responsible for all central engineering work connected with Borden Chemical operations overseas.

Martin D. Schnall, president and general manager of Great Eastern Lumber Company, Inc., North Creek, N.Y., has recently reported the appointment of **John R. Curry,** consulting forester of Saranac Lake as forester and log buyer for this firm. Mr. Curry will handle the procurement of hardwood logs and stumpage throughout the Adirondack territory.

Vancouver Plywood Co. has established a specialties sales department with **Ted Allen** as manager, it was reported by **Donald I. Plummer,** general manager of the firm. The new department will handle the national sales of hardboard, particle board, specialty plywoods, imports such a lauan, and other exotic woods.

Tinsley W. Rucker III, president of Dixon-Powdermaker Furniture Co., Jacksonville, Fla., has been named 1960-61 president of the National Association of Furniture Manufacturers. He succeeds **Harold Sprunger,** executive vice president of Dunbar Furniture Corp., Berne, Ind., who becomes ex officio member of the Board and executive committee.

H. E. Bovay, Jr., partner of H. E. Bovay, Jr., Consulting Engineers, announced that **George C. Love** has been transferred from Houston to the firm's Richland, Washington office, replacing **Robert O. Grimes** as Chief Engineer. Grimes now assumes his former position as Associate of the Bovay Houston organization, and has resumed his duties as Senior Projects Manager to **Charles A. Lawler,** Partner.

Dr. Augustus B. Kinzel, Chairman of the Division of Engineering and Industrial Research, National Academy of Sciences-National Research Council, has announced the appointment of **Harry B. Zackrison, Sr.,** Supervisory General Engineer, Office of the Chief of Engineers, Department of the Army, as 1960-61 chairman of the Building Research Advisory Board. As chairman, Mr. Zackrison will supervise the continuing activities of the Board. He succeeds **William Gillett,** Fenestra, Inc., Detroit.

EMPLOYMENT *Opportunities*

Positions Offered

E-402—Sales trainees age 21 to 35 to join century-old company serving the retail furniture dealers. Training held in company showrooms and factory, leading to excellent selling career. Furniture experience preferred, but not necessary. (Nov.)

Employment Wanted

595—Position desired in production or quality control in wood manufacturing or wood using industry. B.S. in Wood Technology from the University of Michigan and Forestry-Engineering degree from Europe, plus 18 graduate credits in Business Administration. Four years supervisory experience in wood products industry. Married, age 34. (Nov.)

621—Position wanted in plywood production or quality supervision. No degree, but 20 years experience in adhesives research, control and technical service, plus 5 years plywood production control and supervision in pine, fir, hardwood, and specialty mills. Foreign offers invited. Age 46, married, 3 children. (Nov.)

622—Supervisory experience in lumber processing, fabrication, and merchandising. Forestry education. Preference Minnesota or Wisconsin. Age 59. (Nov.)

POSITION OFFERED

MECHANICAL ENGINEER

BY a large forest products manufacturer. Must be capable of supervising small engineering department, making equipment installation drawings and supervising the installation, producing machine drawings suitable for machine shop use, analyzing processes and making written reports to management.

A man familiar with lumber and plywood production preferred.

Excellent salary and working conditions.

Located in Eugene, Oregon.

Send replies to:

E-403, Employment Service

FOREST PRODUCTS RESEARCH SOCIETY

417 North Walnut Street

Madison, Wisconsin

What's New in *Technical Publications*

Single Copies of the Following Reports are Available Free Upon Request from the Director, U.S. Forest Products Laboratory, Madison 5, Wis.

Research at the Forest Products Laboratory has yielded drying procedures for elm lumber that markedly reduce warping during seasoning. Recommendation for dry elm without excessive warping are contained in **Report 1769-26, "Can American Elm Be Dried Without Excessive Warping?"**

Because of the increased use of particle board for purposes requiring decay-resistant material, an appraisal of the decay resistance of various kinds of particle board was made. The results of this research are described in **Report 2196, "Decay Resistance of Experimental and Commercial Particle Board.."**

Recommendations for remedying the warping of plastic-faced panels that have cores of plywood, particle board, or paper honeycomb are presented in the report **"Importance of Balanced Construction in Plastic-Faced Wood Panels," No. 2197.**

In **Report 2189, "Sulfate and Prehydrolysis-Sulfate Pulps for Nitration. Relation of Pulp Characteristics to Certain Preparation Variables,"** an analysis of relations between preparation variables, pulp properties, properties and shredding characteristics of sheets, and nitration quality of pulps is made of various pulps and waterleaf pulp sheets.

The results of an investigation to determine if the existing engineering theory for strength of curved members also applies to a large glued-laminated wood ring are contained in a report, **"Deflection Characteristics of Two 20-Foot-Diameter Laminated Wood Rings Subjected to Compressive Loading Along a Diameter," No. 1877.**

An apparatus that was developed at the Laboratory for comparing, evaluating, and recording the surface imperfections in furniture-type panels with particle board cores is described in Technical Note No. 263, an 8-page illustrated pamphlet entitled, **"FPL Show-Through Comparator for Furniture Panels."**

An evaluation of the presence of tension wood in furniture cuttings, of red oak is contained in Report No. 2193, **"Significance of Tension Wood in Furniture Cuttings of Red Oak,"** Results of research show that although a high percentage of tension wood is found in red oak lumber from southern Illinois, warping generally associated with tension wood does not present a serious problem in these cuttings.

In Report 2194, "A Method of Indirect **Calculation for Use in Log Grade Analyses,"** is described a method of calculating log values in which prices or price relatives are not introduced until the final step of the analysis. As a result, only the final step has to be repeated when the change from one price structure to another is required.

FOR LAUNCHING SALES SATELLITES STANDARDIZE 100% ON SOUTHERN FASTENERS

If you're making sales plans for a new model or new product soon to be launched into orbit, Southern fasteners will help assure its success.

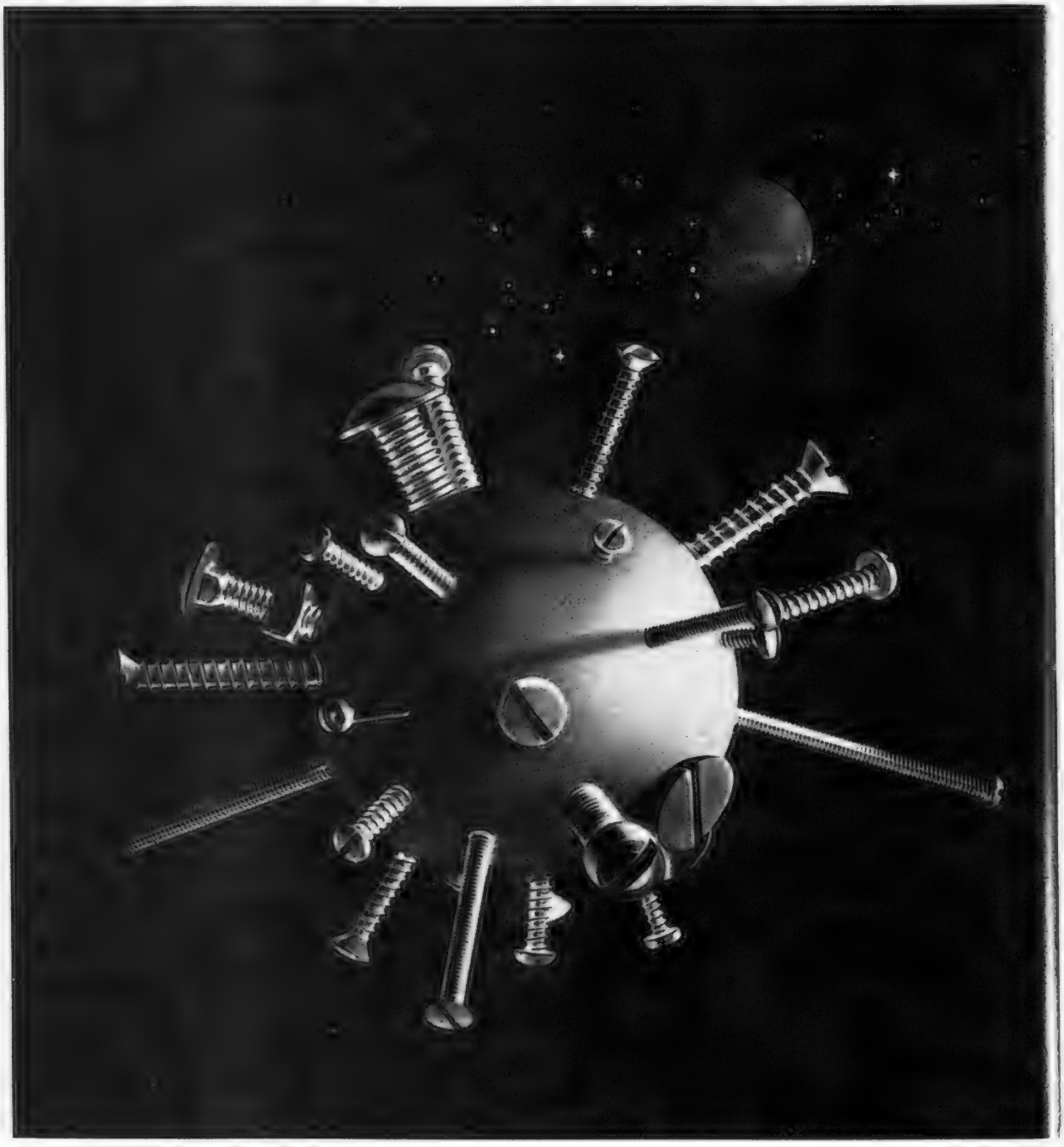
Southern specializes in the manufacture of standard fasteners. Top quality materials and workmanship are combined to produce the most dependable production fastener your money can buy. Burr-free heads and durable threads help step up driving speed in assembly, and thus costly down-time, rejects and injured materials are reduced.

Order USA-made Southern fasteners today. Call your nearest Southern distributor, or write direct to factory: Southern Screw Company, P. O. Box 1360, Statesville, North Carolina.

Manufacturing and Main Stock in Statesville, North Carolina. Warehouses: New York • Chicago • Dallas • Los Angeles.

Southern SCREW COMPANY STATESVILLE - NORTH CAROLINA

Wood Screws • Dowel Screws • Hanger Bolts • Drive Screws • Stove Bolts • Carriage Bolts • Tapping Screws • Machine Screws & Nuts



CROSS SECTION

. . . Voice of Membership

We begin Cross Section, a new voice of membership, with this issue of the Journal. It is more than just a letters-to-the-editor column. It is a place where you, our readers, may discuss Society affairs, present problems, submit solutions, remark on past programs and future plans, as well as comment on Journal articles and editorials. We welcome your contributions.

"Show-Through" Draws Interest

Editor: I have just read in the August issue of the Forest Products Journal, the article on telegraphing of particle board cores. It is a very fine article and I am sure it is a step forward in helping us solve one of particle board's major problems.

K. R. Cooper, Vice President
Roddiscraft, Inc.
Arcata, California

Kentucky Program

Gentlemen: Because of your interest in forests and wood, I want to tell you about recent developments in our State.

The work of the Division of Forestry in the Department of Conservation has been strengthened and expanded. It conducts a program of protection, reforestation, and scientific management designed to improve the forests which cover 45 percent of Kentucky's total land area (11-½ million acres). For the biennium 1960–62, the Legislature has doubled the state appropriation for this agency—an increase of one million dollars of state funds for the two-year period; a total Forestry budget (including Federal and other funds) of $3,130,000.

This significant increase in the appropriation allows the Division of Forestry to: 1) Extend protection from fire to 40 additional counties, which means that nearly 10 million acres of timberland in 90 counties will be protected; 2) Hire 23 additional trained foresters to give greater assistance to timberland owners; 3) Establish a new nursery which will double the forest seedling production capacity and half the time required to reforest the State's idle lands. Our nursery capacity will produce 40 million seedlings a year by 1962. 4) Expand the program to control forest insect and disease pests.

To increase the economic benefits to Kentuckians from the timber they grow, a Wood Utilization Division has been established in the Department of Economic Development. This new agency hopes to expand the wood industry by promoting the manufacture of wood products in the State.

We are convinced that Forestry is on the way to becoming a major industry in Kentucky's economy. At the newly launched Spindletop Research Center at Lexington, preparations are being made for a wood research project. Our purpose in Kentucky is to move forward on the broad front of planting, improved forest practices and management, research and wood utilization. Knowing of your interest, I wanted to bring these facts to your attention.

Wilson W. Wyatt, Lieutenant Governor
Commonwealth of Kentucky
Frankfort, Ky.

New Member

Executive Secretary: We are a relatively new concern, organized about a year ago to manage timber properties for others, to study markets and new and better ways of utilization and manufacture, so that a more complete job of utilization could be accomplished.

At the present time, we employ about 20 men, cutting, skidding, peeling and hauling pulpwood, and cutting and sawing logs into cants for create and pallet mills. We have our own mobile sawmill, peeler, truck, and other equipment, but I am definitely not satisfied with our own operation and am trying to improve our methods. Because we operate on managed property, and because we are trying to improve the timber stands on these properties, we naturally are faced with the problem of utilizing the poorer grade of material.

It is therefore my desire to establish our own plant to more fully utilize this poorer grade of material and also to better use the better grades that we do get. In other words, our interest is to so manage our timber resources that through research and product development, we can profitably use all material that is cut in the woods; and my ambition is to set up a plant that can utilize all of this material at a profit to all concerned.

I am happy to be a member of your society, and I hope that I am able to put into it as much as I expect to get from it.

Clyde W. Rinker
Timber Research & Development Co.
Hart, Michigan

Thanks Employment Service

Gentlemen: Thanks to a contact initiated through FPRS and an ad in the Journal, I have recently began work with the U.S. Tariff Commission as commodity-industry analyst in its Lumber and Paper division.

I wish to take this opportunity to express my appreciation to the Society for this favor and the great help it has been to me in finding a very desirable niche in the field of forest products.

Lawrence B. Sunderland
Adelphi, Maryland

★

CAPITAL MACHINE COMPANY

Established 1887

BUILDERS OF VENEER AND PLYWOOD MACHINERY:

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* Hydraulic veneer slicers
* Hydraulic stay log type rotary veneer lathes
* Full round rotary lathes
* Knife grinders
* Air operated clippers
* Mechanical operated clippers
* Veneer hogs

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CAPITAL MACHINE COMPANY

2801–2837 Roosevelt Avenue

Indianapolis, Indiana

★

A Message from the President

--- **Raymond H. Berry**

PRESENT CONDITIONS IN THE LUMBER BUSINESS have made our Forest Products Research Society not merely an auxiliary to the industry, but the most important, if not the sole, organization directing in detail the way to the future. Today the lumber industry is struggling against three drastic changes of circumstance, any one of which presents a formidable problem:

1) The throttling of the free enterprise system by state and federal taxation and regulation, and by the increasing demands of labor unions;

2) The loss of markets (a) to manufacturers of wood substitutes who make products which the consumer can use or can put in place more cheaply than lumber, without waste and without the need for expensive artisans to complete or to install them, and (b) to foreign competitors whose lower costs for labor and materials cannot be met by American manufacturers;

3) The wastage of valuable raw materials which has always characterized the lumber industry, with the result that only a small percentage of that expensive raw material, the cost of which has risen so sharply in the past decade, has in the past been profitably utilized.

Without entering into a controversy in the field of political economy regarding free enterprise, taxation to support the welfare state or bolster the economies of other nations, or the maintenance of high standards of living for union workers through high wages and costly fringe benefits, let us note merely the fact that Federal, state and even county laws and control have resulted in very high wages and costs, producing marginal returns in cheapened money for those engaged in the free enterprise system. Today, trees shipped from America to Japan are returned to the American market in the form of plywood which undersells by a wide margin American-made plywoods because of labor costs. And today we can buy foreign-made machines and steel for plant construction as good as American products in those fields, at one-quarter less cost than those made here.

Importance of Research

"Free enterprise" as such is not free and its field for enterprise is greatly restricted. For the most part, the only untrammeled activity of management lies in the direction of research—research for new methods, new production combinations, new processes and new products. Wood researchers have been active and fecund in laboratories established by the industry, by forestry schools, by state agencies, organizational agencies, Federal government bureaus, and by private independent individuals and research corporations. Many, if not most of those engaged in this work are members of the Forest Products Research Society. There has been a great deal of duplication of effort, both in fields where the researchers had a common problem and objective and in diverse fields, where processes known in certain lines of endeavor had to be rediscovered for other applications. It is the function of our Society to publicize the work of the many researchers so as to make available for practical application the many results of research not utilized, to prevent useless duplication and to enable free enterprise, through automation, utilization and adaptation, to produce cheaper products at lower costs.

FPRS Is Communication Agency

In a roundabout way only can the socialistic state restrict the activities of management through research The Forest Products Research Society is the communication agency whereby, through its meetings, the

publication of its "Journal" and the services of its national office, the freedom of human ingenuity can be implemented and, in great measure, the throttling of the free enterprise system by an overpowering state, as noted above, avoided.

No one would think of buying a piece of aluminum and hiring a highly-paid skilled artisan to cut off pieces and throw them away to make a useable object, or to extrude aluminum into some form for a specific purpose. What producer of aluminum or steel would think of selling raw metal to the public, so that the consumer-purchaser would have to do just that? And yet, we in the wood industry who manufacture lumber have clung to the methods of our forefathers like religious fundamentalists. We manufacture lumber and put it on the market not as a consumer item but in the old standard grades and random lengths and widths and thicknesses. Because of the high costs of labor and supplies, the lumber itself is high-priced and difficult for the retailer to handle. For its use, the carpenter as a skilled artisan (who has priced himself out of the market) has to be brought in to cut off and throw away pieces in order to make a consumer item. More and more the wood industry has got to realize that if it is to retain its markets for wood, it must make consumer articles or building components that can be put in place without further finishing operations. Otherwise, just as wood has lost its market for telephone booths to metal, and has seen a great increase in the use of metal desks, chairs, ladders, yardsticks and an infinite variety of other items, it will continue increasingly to lose other markets in the future.

Utilization of Residues

Not only does the Forest Products Research Society in its role of industry informant make possible the manufacture of consumer items from lumber, but also from plastics and other materials derived from wood residues or hitherto unused wood fibre from our forests. It is in this latter type of utilization of residues of the lumber mill and the forest that the Forest Products Research Society is of great help to the wood industry. Although general economic conditions and the problems imposed by government and labor unions may create hardship, and although competition with foreign producers and with domestic producers of wood substitutes is still very much with us, the main problem within the wood industry has arisen from the wastage of our great natural lumber resources by the standard lumber mill. Since the 40's there has been recognition that we cannot continue to utilize and convert into a single product only 33 to 35 percent of the standing tree in the woods and only 45 percent of that part of the tree brought into the mill. Gradually, but with ever-increasing pace, the old standard lumber mill is disappearing and the multi-product conversion plant in which lumber may or may not be one of the many products, is taking its place and stopping the great wastage. The development of the present-day monolithic conversion plant enterprises with the mergers, the strangling of the weak mills and the resulting chaos in uncoordinated operations that have been merged, has precipitated a revolution in the wood industry and has created problems as difficult to contend with as are outside competition or governmental restriction. The operating, production and marketing problems of conversion plants in the new era, as well as the principles that would determine their organizaion and size, are the very problems with which certain of our subject matter Divisions of the Forest Products Research Society—to wit. Timber Production, Production Management and Marketing—are concerned.

FPRS is Solution

In summary, then, in all of these three major areas of difficulty mentioned above, the Forest Products Research Society, in a new and dynamic manner, combats the stranglehold of encroaching government and high labor costs, presents the solution to competition with wood substitutes and foreign wood manufacturers, and assists in coordinating and bringing order out of chaos in the new era of the conversion plant and the full utilization of raw material. Our Society is not engaged in preserving archaic survivals or endeavoring to hold fast to past customs in a changing world. It seeks rather to hold fast to those practices which stand the test of use and to give order and symmetry where a dynamic change to better practices is indicated. This makes our Society unique among associations interested in wood. It binds together many disparate interests and makes each component conscious of the problems within the whole industry.

Raise In Dues

To carry forward this program, the Society in its recent activities has taken steps, through the action of its Board, ratified and approved by the membership, to revitalize its functions. The raise in dues proposed by the Executive Board and submitted through steps set forth in the Constitution to the membership, has been overwhelmingly approved by a vote of 1059 to 247. The amendment to the Constitution that establishes the Divisions of the Society is now being voted upon and will, it is hoped, be unanimously approved. When these provisions have received approval, the new Division set-up on the basis of processes rather than of products, will go into effect and give a universality of scientific interest to the discussions which was lacking where the regional interests generated by a product-oriented classification existed. Added to this we have the recommendations of the special Policy Committee, approved by the Executive Board, printed elsewhere in this issue, and to be discussed later in this column.

Our new Executive Secretary has been busily engaged in building up the financial structure of our society and in improving the services of the national office. It is hoped, therefore, that despite the adversities that come from the encroachments of government, the competition of foreign manufacturers and of those engaged in making wood substitutes, and the problems of change within the wood industry, the Forest Products Research Society will foster, for the future, a stronger, sounder and more vital industry.

First International FPRS Meeting Held in Montreal

The first meeting of the Executive Board in Montreal met on Sunday in the St. Charles Room.

His Honor, the Mayor, treated the Society with warm hospitality at his reception, greeting each lady with a rose and each gentleman with a cigar.

Canadian Welcome

As the first Canadian to serve on the Executive Board, J. H. Jenkins welcomed FPRS members to Canada. He told with pride of the part that his fellow Canadians are playing in the Society.

In his welcoming address, Mayor Sarto Fournier spoke of the forest products industry in the United States and Canada, particularly complimenting the research men.

E. I. Holmes and T. Oosterhoff, (second and third from left), signed in some of the 586 registrants before the Montreal Meeting

Past-president E. S. Harrar introduced the Honorable Lionel Chevrier as Official Luncheon Speaker.

National Meeting Committee

National Meeting Commitee Chairmen: front row, l. to r: A. J. Petch. C. B. Dyas; W. E. DeCelles; D. K. Saunders; E. I. Holmes; J. F. McCracken; D. D. Lockhart; rear, G. Lemay; C. Bird; R. H. Gray; V. H. Bushell; A. Chaput; T. Oosterhoff.

D. K. Saunders, president-elect, R. H Berry, president and T. S. Veazey, vice-president, top officers of FPRS.

FPRS Fourteenth Annual Business Meeting

The 14th Annual Business Meeting was called to order by President Harrar at 11:30 A. M., June 6, in the Marquette and Joliet Rooms of the Queen Elizabeth Hotel. A record attendance for a business meeting of two hundred persons was achieved.

1. **Minutes of the 1959 business meeting.**

The preceding annual business meeting was held in San Francisco, June 29, 1959. The minutes of that meeting were published in the October, 1959 Forest Products Journal. It was moved and seconded that these minutes be approved. Motion carried.

2. **Annual report of the Executive Secretary**

Frank J. Rovsek, Executive Secretary, Madison, reported that the Society membership and subscriptions increased from 3700 on January 1, 1959 to 4100 as of January 1, 1960. He emphasized the important role the subject matter divisions have played in the Society in the past year, mentioning the Wood Machining Abstracts, and the Chemical Utilization bibliography which appeared in the February Review issue of the Forest Products Journal. Mr. Rovsek praised the organizational growth of the Society and predicted a successful future.

3. **Report of the Budget and Finance Committee**

Chairman W. J. Eason reported that the Society's accountants, Mr. V. C. Hobert and Mr. I. H. Guthneck, had prepared the annual audit of the Society's financial records and that the operating statement and balance sheet have been published in the April issue of the Forest Products Journal. In the first 3 months of 1960, the Society achieved $15,211 of income and expended $22,827, resulting in a net deficit of $7,615. Mr. Eason noted that this deficit would have been greater had it not been for the financial success of the exhibit and attendance at the 1959 National Meeting. He emphasized that in the current year efforts are being made to balance the budget.

4. **Report of Division Coordinator**

Chairman Donald K. Saunders, coordinator of the Society's divisions, announced action of the Executive Board to realign the Society's division into generic-oriented rather than process-oriented groups, which will result in greater flexibility of technical programs. Further, it will provide a place in the Society for interest of all phases of technology.

Past President E. S. (Scotty) Harrar congratulates President R. H. Berry as he hands over the chief executive's gavel. Looking on are D. K. Saunders, president-elect, and T. S. Veazey, vice-president. The Honorable Lionel Chevrier watches in the background.

5. **Report of Montreal Meeting Committee**

D. K. Saunders, General Chairman of this International Meeting, reported on the statistics of the meeting. He expressed the regret of the Executive Board for any minor misunderstanding resulting from the new "package" registration plan, and indicated that it was the desire of the Board of future National Meetings to provide two types of package registrations—one for men and their wives, and the other for men attending alone.

6. **Constitution and By-Laws Committee**

J. J. Allegretti, Chairman, moved that the Constitution be amended to incorporate dues increase from the present $15.00 to $20.00 for voting and associate members, and that a new Article XI be added to the Constitution, providing for the legal recognition of subject-matter divisions. He stressed that the primary need for the dues increase was to balance the operating budget and provide for a substantial increase in publishing of editorial material in the Journal, as has been recommended by the Publications Committee.

7. **Report of the National Membership Committee**

T. S. Veazey, Chairman, announced that the total gross membership of the Society had risen from 3,478 in June, 1959, to 4,175 in June, 1960. He presented certificates of appreciation for Section membership activity to the following: First, Pacific-Southwest; second—Mid-South; third—a tie, Great Lakes and Northern California.

8. **Report of the Publication Committee**

The annual report of the publications Committee is printed elsewhere in this issue. As stated there, the Committee's major effort resulted in the preparation of the Official Publication Policy, which was published in the July issue of the Journal.

Dr. E. G. Locke, Chairman, announced that he had informed President R. H. Berry, that he could no longer devote the time to the chairmanship that the job deserved and had asked that his name be withdrawn.

9. **Editor's Report**

As of May 25 we had a 7-month backlog of papers on hand, compared with an 8-month backlog a year ago. The total number of pages of editorial material, 277, is but 9 less than it was for the corresponding period a year ago. An intensive effort is being made to get the Journal on schedule, and new features, such as a membership communications page, are planned for the future.

10. **Tellers Committee**

This report was made by Robert De Grace, Chairman. The following were elected officers for 1960-61: President—R. H. Berry; President-Elect—D. K. Saunders; Vice-President—T. S. Veazey; Northeast Board Member—Eric Anderson; and Northwest Board Member—Robert Seidl.

Elected to the National Nominating Committee were F. F. Wangaard, P. L. Northcott, R. H. Ripley, and S. B. Preston.

11. **Report of the Resolutions Committee**

James Hamilton, Chairman, read the report:

1) The Society records with deep regret the passing during the past year of the following members: George Hood, J. B. Alexander, Walter W. Smith, Tom H. Chapman, Julius Bergsma, E. B. Wait, Joseph Coufal, and W. L. Lear.

Be it resolved that this expression of sympathy to the families and friends of those members be included in the permanent records of this meeting and of the Society.

2) In appreciation of the meritorious services that have been rendered to the FPRS during their term of office, but it resolved that the gratitude of the Society be extended to each of our outgoing officers, including Executive Board Members, Section and Division Officers and Committee persons.

3) Recognizing that the success of this First International and 14th Annual Meeting is a large measure due to the foresight, planning and diligence of the Annual Meeting Committees, be it resolved that the Society hereby acknowledge its appreciation to the members of our Eastern Canadian Section and the other Canadian organizations that cooperated in the planning and conduct of this meeting, for their excellent and successful work.

4) In view of the splendid cooperation and the services provided by our host hotel, the Queen Elizabeth, and our 50 Paul Bunyan Hours Sponsors,

Be it resolved that the appreciation of the Society be extended to the management and staffs of these organizations.

Finally, be it resolved that the gratitude of the Society be extended to each and every author and Committee worker who has worked so diligently to achieve the success of this meeting.

The meeting was adjourned at 1:30 p.m.

Official Statement of FPRS Policy

Approved by the Executive Board June 6, 1960

At the meeting of the Executive Board of the Forest Products Research Society at the Conrad Hilton Hotel in Chicago, Illinois, January 19 and 20, after discussion, a resolution was passed that the President appoint a committee to recommend to the Executive Board a long-range plan for the future to be submitted at the Montreal meeting. Under this resolution, your Policy Committee submitting this report met at Denver, Colorado, at the Park Lane Hotel, on April 7 and 8, 1960. Committee members were: R. H. Berry, D. K. Saunders, W. J. Eason, and W. R. Smith.

In order to include all interests represented in the Society, and so as not to omit anyone's interest in various aspects of research, your Committee felt that the membership falls into the following groups. Some members may well have interests in more than one of these groups.

I. Membership

A. Teachers, professors and school men
B. Students
C. Full-time researchers
   1. From laboratories of wood industries and suppliers.
   2. From laboratories of the State and Federal government agencies
   3. From laboratories of forestry schools
   4. From private (individual or corporate) laboratories engaging in research.
D. Administrative and productive men from industry
E. Wood plant suppliers
F. Professional foresters and extension foresters

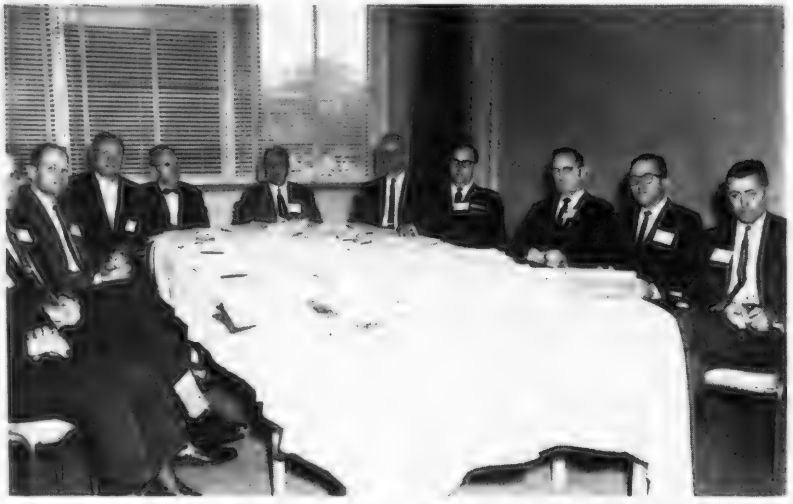
The Committee felt that the foregoing classifications represented all of the membership interests and that in its deliberations the Committee should, in advancing the objectives of the Society, see that each member-interest group was brought into the full activities of all branches of the Society's program so as to weld the membership with regard to research into a seamless and partitionless whole.

II. Objectives of the Society

In discussing the objectives of the Society, your Committee carefully read and considered the objectives as set forth in the national constitution. These objectives are very broadly stated and do not limit the Society in promoting an interest in research. Your Committee feels that the objectives of the Society are well stated in the constitution and that the sole problem of the Society is to provide implementation and see that the implementation occurs. In fact, the constitutional objectives, as stated, permit the Society to engage in activities much more expanded and in excess of what the Society is now doing. Your Committee feels that this is desirable and points the road to growth and expansion.

III. The Means or Methods to Reach the Objectives

In our deliberations, the Committee had the benefit of written suggestions from many members in response to letters of inquiry sent out by Committee members, W. J. Eason and D. K. Saunders. The answers to these letters, which were quite numerous, had been reviewed and summarized by both recipients and the Executive Secretary who made a report. These were used in the discussion from which the following recommendations are made. Your Committee feels that in line with the stated objectives of the Society, it is our purpose to promote better understanding and better exchange among the diverse membership of the Forest Products Research Society.



The Executive Board met on Thursday to discuss FPRS policy. Left to right, Carl Trinkle, F. E. Dickinson, A. F. Muschler, W. R. Smith, E. S. Harrar, R. H. Berry, D. K. Saunders, J. L. Love, E. A. Anderson, F. J. Rovsek, and T. S. Veazey.

A. Through publication of the "Forest Products Journal": Practically all comments included the Journal. The membership and your Committee felt that it was one of the most important, if not the most important, means for the integration of the Society. The correspondence received regarding this will be referred to the Publications Committee. W. R. Smith, who has been for some time a member of the Publications Committee, made a resume and report of the activities of that Committee for the benefit of the Policy Committee.

The Policy Committee recommends that the Publications Committee shall consist of preferably 6 but not more than 10 members of the Society, to be selected by the National Board and to represent all the various interests of the membership and, where possible, the Regional divisions of the Society.

The Committee further recommends that the Editor of the "Journal" be ex officio an additional member of the Committee and that he meet with the Committee.

It is further recommended that the Publications committee be instructed by the Board that all of its decisions and recommendations be presented in writing, with or without personal appearance by the Chairman, to the Executive Board for consideration at the next Board meeting after the Committee has met and acted. It is also recommended that the Publications Committee observe the following as matters of policy:

1. That it make recommendations to the Board concerning editorial policy, with due regard to the interests of all members of the Society.
2. That the Publications Committee hold at least 2 meetings per year, or more if the Chairman shall deem necessary.
3. That the Chairman shall, at all times work closely with the editor.
4. That the Publications Committee have the responsibility for setting up procedure for reviewing original papers which are submitted for publication.

Responsibility for editorial policy shall be solely the function of the Executive Board, which will act on recommendations of the Publications Committee. The administrative operation of the "Journal," (sales, advertising, and financial matters) shall be handled by the Board through the Executive Secretary.

1. Administrative Publications: Other publications of the Society which shall be classified as "Administrative" shall be handled by the Board through the Executive Secretary as part of his administrative function. This includes the "News Letter," manuals, and all other forms of publication.

B. Meetings: 1. National: Consideration was given by the Committee to the many recommendations made in answer to the inquiries noted above. There was great inconsistency and diverse opinion in these recommendations, some emphasizing the technical and others the social functions of the meetings. It was felt that proper balance should be maintained to keep and satisfy the interests of all the membership.

Considerable discussion arose from the suggestion of members that some form of preprints of all papers given at the national meeting be made available to the members, but that the speaker at the meetings shall make a brief presentation and that, with the benefit of preprints, those in attendance carry on discussion from the floor.

It is suggested that the question regarding preprints, brief presentation, and enlarged discussion be referred to the Society for a letter vote by the members-at-large.

Your Committee emphasized that the annual meeting is an important function of the Executive Board and that the present policy of organizing a national meeting through an appointed Chairman be continued, but that it be understood that the Chairman need not necessarily be a member of the Executive Board.

It is further recommended that the Chairman of each meeting be appointed not longer than two years prior to an annual meeting and that in forwarding the details of organization of each meeting the Executive Secretary shall give such assistance and advice as he can when requested by the Executive Board or the Meeting Chairman.

2. Regional Meetings: Your Policy Committee recommends that the Board encourage these meetings when they appear to be in the interests of the Society. The Committee feels that joint meetings with other organizations or societies may be held in a Region, but that they should be approved by the Regional Board Member before being set up.

3. Sectional Meetings: Your Policy Committee recognizes that strong sectional activity is the source of the Society's strength and for that reason recommends that the Executive Board encourage and assist the Sections in the development of their activities. Numerous suggestions have been written in by the members to the effect that small, regular, periodic meetings should be encouraged and that in all meetings research as a tool for development should be strongly emphasized. The assistance that may be obtained from the Executive Secretary in Sectional meetings is referred to later under "Services." Whenever possible, the Regional Board member or some other national officer of the Society should be asked to bring the Section up-to-date on national matters, or if an officer is not available, a letter should be obtained from the Regional Board Member. It is further recommended that in holding meetings, the By-Laws of the Sections be observed and carefully adhered to.

Service of National office: At present it is recognized that from the national office, through the Forest Products Journal there is available to the membership a medium for advertising, for notice of Sectional and other meetings, and in general, a means of Society communication. The national office will also, through the Executive Secretary, give prompt aid and assistance for the conduct of meetings, and in connection with that will, for a charge, furnish reprints of papers or do multigraphing or other printing services. The national office will also continue, as heretofore, the Employer-Employee services it has furnished and it will endeavor to maintain an up-to-date listing throughout the country and, if possible, elsewhere, of all appropriate services to which technical inquiries made by members can be referred.

The national office also will assist in the cooperative functioning of the Sections and Divisions or any of the Committees of the Society by maintaining lists of speakers, experts on technical subject, bibliographies, etc., in the work of the Divisions and Sections.

Other possible services were discussed, some of which it may be hoped will find expression in the near future when they may become economically feasible.

IV. Administration

A. *The Function of the Executive Board, the Executive Secretary, and the Officers:* The constitution and by-laws of the Society set forth in detail the functions and responsibilities of the Executive Board, the officers and the Executive Secretary. Your Policy Committee felt that more executive attention should be given by the Board and the Officers to the affairs of the Society. The Policy Committee, therefore, recommends that the Executive Officers take a more active interest in their duties as prescribed by the constitution and by-laws and that the Executive Secretary, whose duties are likewise prescribed, limit his functions to carrying out the policies set by the Executive Board and by the presiding officer in the interim between Board meetings.

B. *Reports to the Executive Board and Officers:* 1. Committees: Your Policy Committee recommends in general regarding Standing Committees that the Chairman may or may not be a member of the Board, but that Standing Committees shall be composed of Society members and be chosen by reason of their personal qualifications and that committee be small and workable and, as a rule, include not more than 5 or 7 members.

Except for Nominating Committees and Section and Division Advisory Committees, as provided for in existing or proposed constitutional and by-law provisions, Standing Committees should be as follows:

a. Publications Committee
b. Budget and Finance Committee
c. Membership Committee
d. Constitution and By-Laws Committee
e. Industry–Education Committee
f. Employment Committee.
g. Public Relations Committee
h. Ways and Means Committee

Wtih regard to committee functioning, your Policy Committee recommends that the Committee Chairman shall submit at each Board meeting a report in writing of the decisions and recommendations of his Committee. In this connection, it should be noted that it is recommended that the Executive Board have 2 meetings at each Annual Meeting, one meeting in the Fall and one meeting in the early part of each calendar year.

C. *Expenses:* The Policy Committee recognizes that the foregoing recommendations entail considerable added expenses to officers, committee members, and Chairmen. For this reason it recommends that the Ways and Means Committee be instructed to submit to the Executive Board estimates to be included in the annual budget, to as accurate an extent as possible, to cover the additional expenses incurred by officers, committees, and committee Chairmen.

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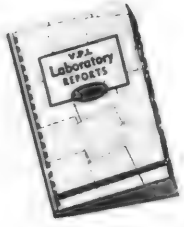

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FPRS SECTION OFFICERS' MEETING

The meeting was convened at 8:00 A.M. June 6, under Chairmanship of J. Allan Hauter, Northeast Section. It was devoted to discussion of matters of current interest to the Section Officers.

The proposed dues increase, and more particularly a policy on the portion allocated for Section operations was discussed rather thoroughly, resulting in the motion

Moved: That the Section Officers express concurrence with the part of the constitutional amendment presented at the 14th Annual Business Meeting, stating that the portion of each member's annual dues allocated to the Section be uniform among the Sections. Further, that we recommend to the Executive Board that when this amendment to the constitution is sent to the membership for ratification the need for the increase be spelled out clearly and a detailed Society financial statement be included to show the need for this dues increase. The object here is to give the individual member justification for this dues increase, which we recognize as necessary to effective F.P.R.S. operations.

Seconded and carried without dissent.

The subject of effective Section program planning, meetings, and membership development was of interest and concern. An exchange of ideas and suggestions on this subject followed. The cost of membership development was reported to range from $10 to $30 per new member. Although this might appear costly, it was pointed out that this cost spread over the expected period of continuous membership of each new member could be readily justified. Accent was given to the importance of keeping member interests. Some Sections publish Section Member Newsletters and make a special effort to keep in personal contact with all their members, with a view to keeping well informed on their interests. In view of the Sections' investment in recruiting, members' effort expended to keep old members could easily be more justifiable than some recruitment. It was pointed out that recruitment policy should concentrate on men with good possibilities of continuing interest and membership. This would not only be economic good sense, but would result in a higher level of participation and activity by the general membership. All Section Officers expressed a desire to receive copies of the meeting programs of other Sections so they could study format as well as program content. Some time was devoted to the matter of good communications with F.P.R.S. Headquarters, availability of aids and services to Section Officers and the new mechanical facilities in Madison for membership list breakdowns by different categories. Out of these discussions came three resolutions as follows:

Moved: That arrangements be made for the forwarding of Section Meeting program announcements and Section Member Newsletters to officers of all F.P.R.S. Sections, either by the inclusion of the Section Officers' Newsletter mailing list with all Section program and Section Member Newsletter mailings handled by the Madison office and/or by appending this list to mailing lists requested by Sections which handle their own program and Section Newsletter mailings.

Seconded and approved without dissent.

Moved: That the frequency of routine distribution of membership lists to Section Officers be limited to four times a year and that a high level of accuracy be encouraged in the preparation of these lists.

Seconded and approved without dissent.

Moved: To stimulate a high degree of Section Officer interest and performance we request the F.P.R.S. Headquarters office supply each new Section Officer with a kit of Section Officers aids (literature) with a personal letter recognizing his election as soon as possible after receiving notice of his election. In this way the Section Officers' responsibilities will be emphasized and the support and interest of his work by the National Office will be evident.

Seconded and approved without dissent.

A recent communication from the Madison office to the Sections' Treasurers to the effect that the Section funds be retained on account by the Headquarters for purposes of accruing interest, unless specifically requested by the Sections, was discussed at some length. The group seemed to have no objection to a policy for achieving some income which might otherwise be lost. However, it was mentioned that no seemingly adequate explanation of the procedure had been furnished. A motion followed:

Moved: It is requested that the Executive Board investigate the deferment of payment of Sectional portion of annual dues with a view to placing these payments on a regular quarterly basis. This is a matter of procedure clarification.

Seconded and passed. (One dissenting vote)

A proposal to require appointment of a Sectional Representative of each Subject-Matter Division to function within each Section, emanating from the Executive Board, received considerable attention. Information was sought as to status of this proposal and its purpose. The idea that we should avoid developing a policy of servicing requests for technical advice to industry in this manner was expressed. The need for this feature of Section organization was questioned. A motion was formed:

J. Allan Hauter reads the report of the Section Chairmen at the Section Officers-Executive Board luncheon.

Moved: We request from the Executive Board clarification on the activity to be carried out by the proposed technical advisory representatives within Sections.

Seconded and approved without dissent.

A final resolution pertaining to the current meeting arrangements was drawn up. It was agreed that meeting facilities at Montreal seem highly satisfactory and the following motion is of a constructive nature. The Section Officers did not see the advantage to the procedure followed, since at-the-door registration was possible in addition to advance registration.

Moved: We inform the Executive Board that we oppose the policy of a single registration fee, without regard to attendance of wives.

Seconded and passed with dissent.

There were no further motions. A policy which might be adopted within Sections to furnish financial aid to enable some members and student members to attend National Meetings for the purpose of presenting papers was discussed. It was suggested that this matter be carried back to the individual Sections for exploration.

It was also suggested that appropriate news items be submitted to the National Headquarters for inclusion in the Section and Division Officers' Newsletter. It was recommended that ideas and experiences relative to improvement of Section Meeting activities and membership development would be especially valuable.

Members in attendance were:

Victor H. Clausen—Northern California Section (V. Ch.), William R. Francis—Pacific Northwest Section (Ch.), Don Burnet—Pacific Northwest Section (Sec.), Ralph Peter—Southeast Section (Ch.), E. Brooks Applegate—Great Lakes Section (Ch.), Hereford Garland—Great Lakes Section (Tr.), Carl Johnson—Great Lakes Section (—), Robert J. Hoyle—Inland Empire Section (Ch.), William C. Hopkins—Mid-South Section (Tr.), H. Dale Turner—Mid-South Section (V. Ch.), R. F. DeGrace—Eastern Canadian Section (Ch.) and Wayne L. Meek—Upper Mississippi Valley (Ch.)

The meeting was adjourned at 10:15 A.M.

FPRS members and their wives greet friends at the Host Reception sponsored by the Eastern Canadian Section.

The Wood Award winners, William McKenzie and Robert Kellogg (front) line up with their judges and faculty sponsors, Back row, left to right: N. C. Franz, Everett Ellis, S. B. Preston, and Eric Ellwood.

Highlights of Business and Pleas re at

Registrants from the Great Lakes, Midwest, and Upper Mississippi Valley Sections are joined at the Official Banquet by Vice-President T. S. Veazey (center).

Honored speaker, Dr. A. J. Stamm, gave this year's Honorarium Lecture, sponsored by the Midwest Section. His subject was "Fundamentals of Moisture Movement in Wood."

Convention delegates crowd in front of the registration booth, while registration crew members answer questions, type badges and make lists.

Membership Chairman T. S. Veazey gives the first place Membership Award to F. E. Dickinson, who is accepting for the Pacific Southwest Section. Holding their awards are E. Brooks Applegate, Great Lakes, and V. H. Clausen, Northern California, whose sections tied for third place. Second place was awarded to the Mid-South Section.

V. C. Hogren, executive vice-president of *Hitchcock's Wood Working Digest*, announnced the annual Hitchcock Research grant, a $500 award to be given annually to a recepient selected by the Society.

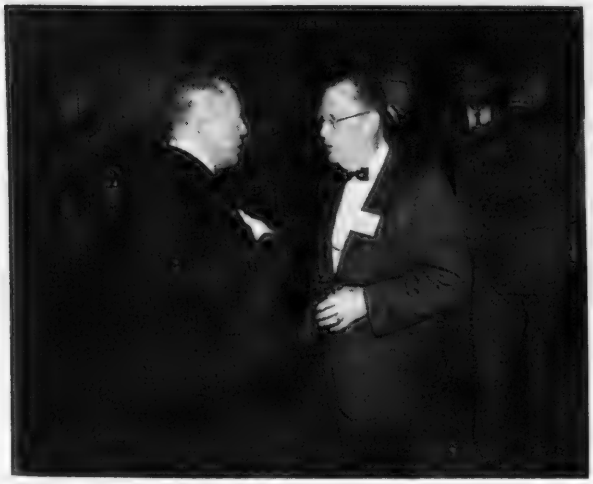
William McKenzie, University of Michigan, right, beams as he receives the Eleventh Annual Wood Award from J. F. Koellisch, editor and manager of *Wood and Wood Product Magazine*.

Fashion designer, Raoul-Jean Foure conducted a fashion show at the Ladies Luncheon.

A. J. Stamm, R. F. Blomquist, W. R. Smith and a friend seem to be enjoying the Paul Bunyan Cocktail Hour.

re at the 1960 National Meeting

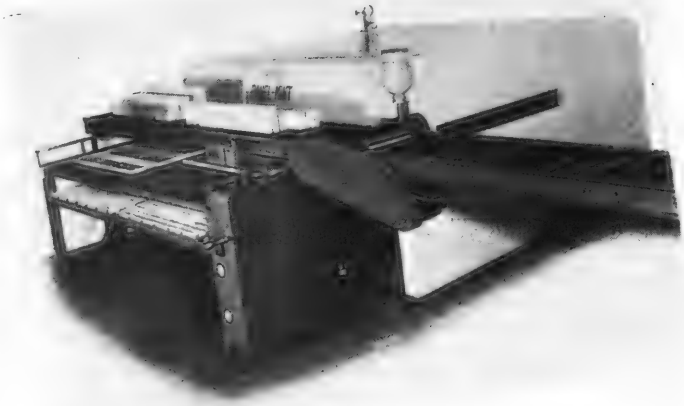
A view of members and guests at the Official Luncheon, held in the Marquette and Jolliet Rooms at the Hotel Queen Elizabeth.



he present president and the past president talk business during the FPRS Host Reception.

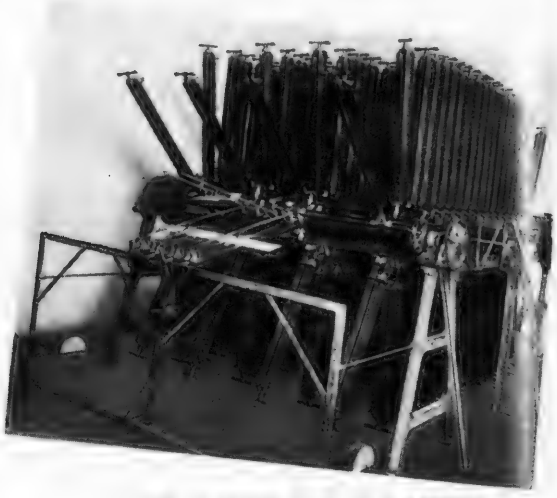
New York State College of Forestry, Syracuse held a reunion dinner.

LOOK TO TAYLOR FOR MACHINES IN



THE TAYLOR PANEL-MINT

Batch Type Edge Gluing Press. For wood 4½' x 7' x 3" thick. Unequalled for one-man production. Air-operated and steam-heated, simple design assures minimum maintenance. Combined with automatic reversing glue spreader permits low cost gluing by one man alone.

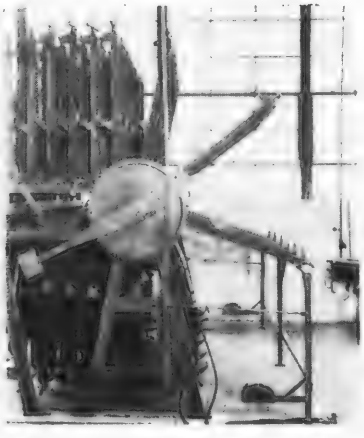


THE TAYLOR CLAMP CARRIER

Endless conveyorized storage of clamped panels up to 20' long x 4' wide x 6" thick. Almost completely foolproof; time proven machine for edge gluing and laminating. Uses any type of glue. Very versatile for small or large production. Built in many sizes.

THE TAYLOR AUTOMATIC CONVEYOR TYPE GLUE APPLICATOR

For edge gluing and laminating. Uniformly coats large quantities of stock for the fastest gluing operations. Supplied in many sizes for Hot or Cold glues.



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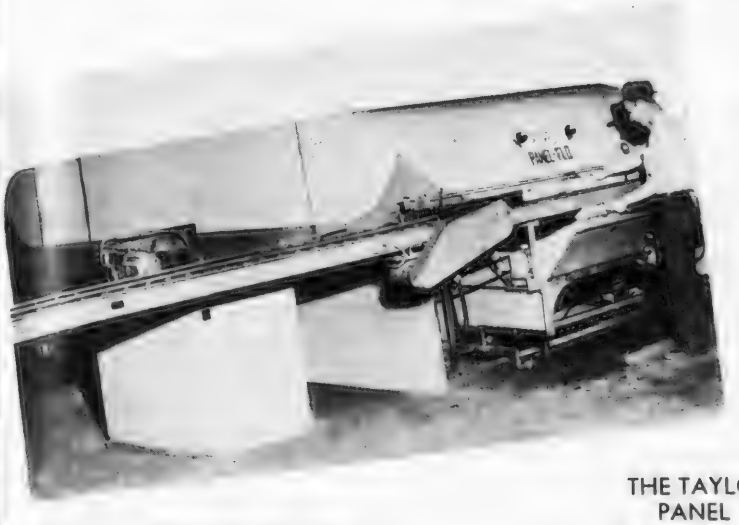
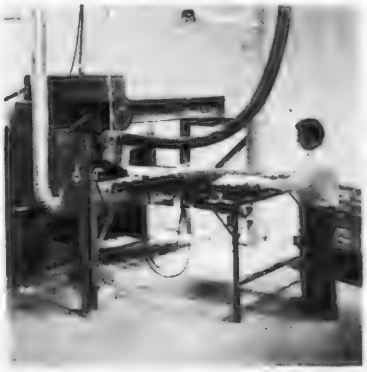


THE TAYLOR PANEL-FLO

Continuous feed steam-heated edge gluing Press. Any width panel x 8' length x 2" thick. Unmatched for output. Trouble free continuous production up to 4000 ft. per hour. Panel size and thickness changes require minimum of set-up time. A "must" for high production conveyorized gluing operations.



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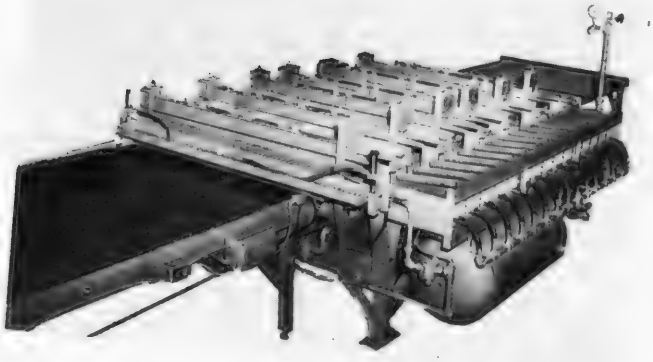

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For edge gluing or laminating long lumber up to 20' in one cycle. Glues to 4½' wide and 4" thick. Air operated and steam heated.

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Technical Sessions and Division Meetings

Session XV, Wood Composition Board "B", back row; C. S. Goyder; S. H. W. Brooks; C. C. Booth, recorder; front row: O. B. Eustis; J. R. Roberts, chairman; E. T. Ruffin.

Session XVI, Quality Control: E. R. Hansen; N. D. Jackson; J. R. Stillinger, chairman; B. C. Borden; Gilbert Tardif; G. W. Smith recorder.

Session III, Packaging: R. S. Kurtenacker; Karl Bollerslev, chairman; F. A. Gilhooley; Albert Kner.

Session IX, Glues and Gluing "A": R. F. Blomquist; F. F. Wangaard; B. A. Jayne.

Officers, John Lutz and Harold Evans, past officers of the Veneer and Plywood Division, discuss the new organization of subject matter divisions.

Session X, Lumber Manufacturing: J. R. Bemis; George French; M. H. Mater, chairman; J. R. Jenkins; S. F. Rook; J. A. Doyle; Paul Heller, recorder.

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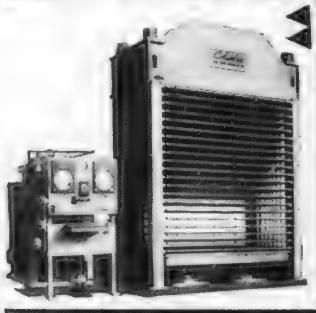

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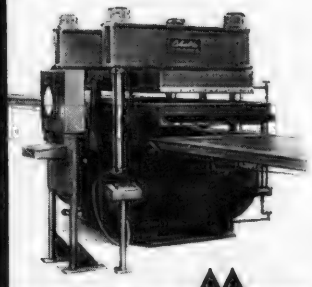

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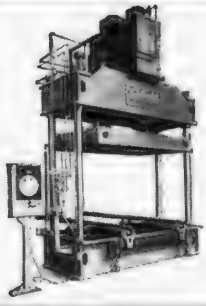

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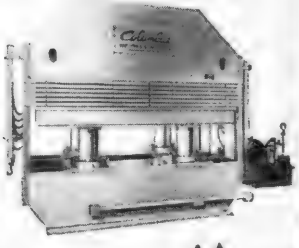

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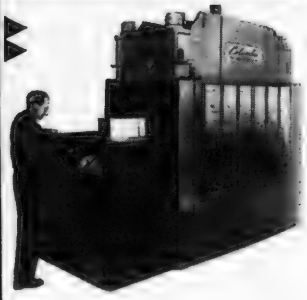

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VARIOUS WOOD PRODUCTS, VENEERS & FIBRE BOARDS

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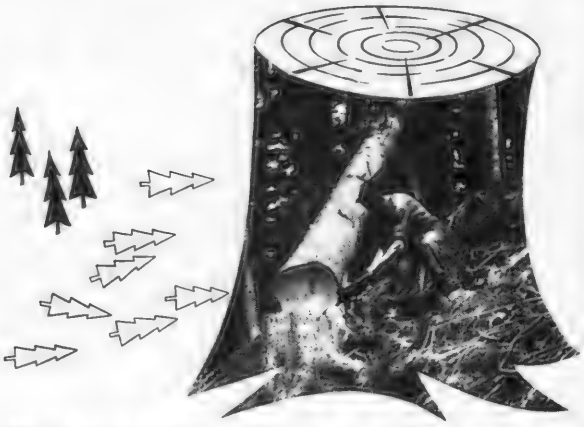

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have never been easy to coordinate but Hardboard manufacturers are closing the gap. Low cost Hardboard production is now a reality in which economical Drying plays a most important role.

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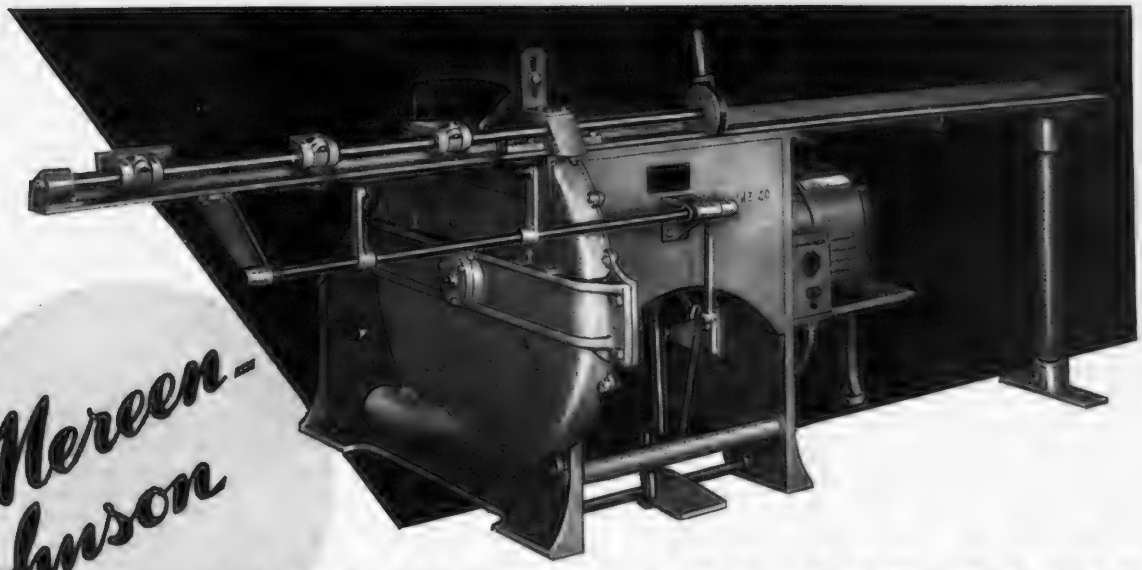
Session XIII, Logging, l. to r.; T. N. Baker; D. R. Elliott; J. A. Doyle, chairman; W. W. Calvert, recorder; T. C. Scheffer; P. H. Lane; and S. J. Simons.

Session XIV, Industry-Education. R. N. Jorgensen, recorder; George Garratt; E. S. Johnson; E. Ellis, chairman; H. O. Fleischer; P. R Beattie.

Session XVII, Wood Drying: S. B. Preston; R. S. Millett, chairman; W. C Hopkins; G. Billington; A. J. Stamm; H. H. Smith; L. D. Espenas.



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The greater your production . . . The greater the saving

- **Ideal for any production cross-cutting operation.**
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- **Includes new retracting stock support**

THESE MACHINES have a capacity equal to two or three swing, straight line or roller carriage cut-off saws—depending on the condition of the stock. They are particularly efficient wherever short lengths are cut from long boards in quantity production. Two saws, mounted opposite from each other on a revolving yoke, make alternate cuts. Each saw disappears beneath the table as it cuts. The operator never has to wait for the saw to return to the back position, as is the case with an ordinary reciprocating type of machine. The stop lever at the operator's left hand leaves the right hand free to handle the stock. *Available in two models: No. 477, 17" wide. No. 478, 23½" wide.*

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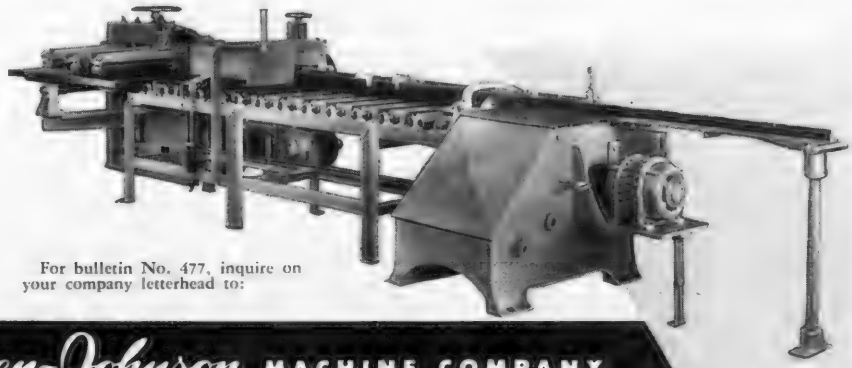
Automatic cut-off saw, gang rip saw and automatic hopper feed for gang rip saw. The stock leaving the cut-off saw drops onto the bed of the automatic feeder. This in turn feeds into the rip saw—eliminating the off bearer of the cut-off saw and feeder of the gang rip saw. Note the saving of two men in this operation.



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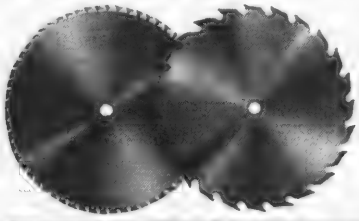

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A famous name in precision tools since 1888

Session V. Wood Composition Board, "A", l. to r.: R. W. Young, recorder; Wayne Lewis; James Roberts; E. S. Johnson; and James Hamilton.

The steering committee of the new Wood Composition Board Division poses during their formative meeting: J. R. Roberts, retiring chairman; Wayne Lewis, vice chairman-elect; M. M. Yan, Kjell Stordalen; James Hamilton; and H. C. L. Miller.

Session IV, Chemical Utilization "A". Claire Canty, recorder; R. C Linkhart; Burton Wilner; P .H. Lane; Joseph Shulman; F. G. Perry, Jr. chairman.

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The "rule of thumb" methods of the inexperienced, or the "engineering rules" of an experienced design, fabrication, and installation firm—which will you select for your dust control problems?

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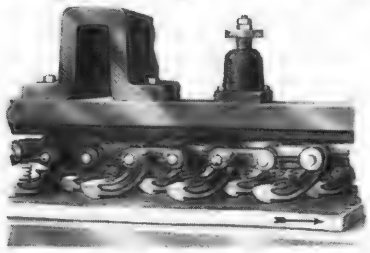

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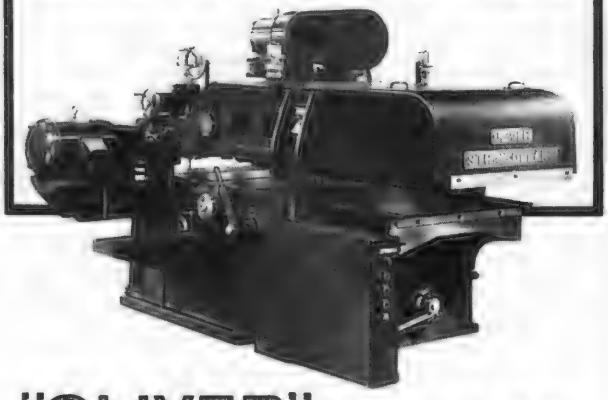

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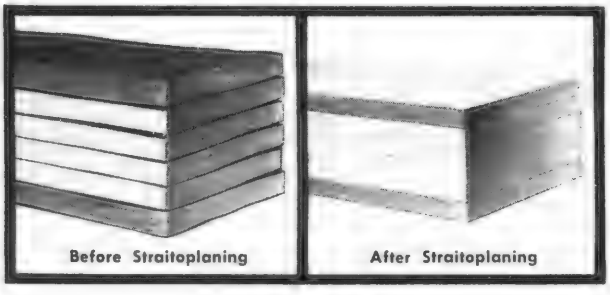
planes both sides of warped stock smooth and parallel — at the same time!

In one pass the "Oliver" Straitoplane takes raw stock out-of-wind and planes both sides smooth and parallel — it does the work of a facing planer and a single surfacer. It planes out as much as ¼ inch on each side at speeds up to 90 feet a minute. The bottom side is face jointed, and the top side planed smooth to the desired thickness.

The Straitoplane will plane warped or straight stock simultaneously on both sides up to 36 inches wide, and from ½ to 6 inches thick. It planes both sides of pieces as short as 12 inches when fed continuously, as short as 16 inches when fed singly.

Write today for complete information.



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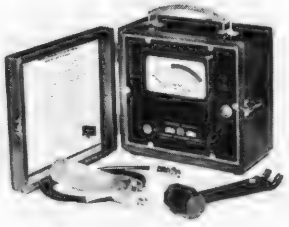

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For Every Moisture Test On Wood

MODEL RC-1: Long moisture range 6–65%. Tests as low as 4% on hot lumber. Direct reading. ACCURATE: Self-calibrating circuit compensates for change in battery voltage. For use in kiln operation, manufacture of furniture and precision wood parts.

MODEL G-2: Practical moisture range 7–30%. COMPACT: Size of a camera—easily carried with neck strap —recommended where utmost portability is required. RUGGED: Housed in a durable aluminum case.

ELECTRODES: Used interchangeably with either meter. ADAPTABLE: Can be used to measure moisture in all kinds of wood from veneers to heavy timber.

KIL-MO-TROL: Complete system. Measures lumber moisture content without entering kiln, without kiln shutdown.

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Solid **Fiberesin*** offers you a unique advantage . . . it is a complete solid panel which affords you complete freedom in your thoughts and ideas. The solid **Fiberesin** panels are simply cut to the shape desired and the solid edges profiled to what your design dictates. Solid **Fiberesin** offers you a wide range of thicknesses to meet either aesthetic or structural requirements. Solid **Fiberesin** is solid plastic with a beautiful, flat, satiny surface that reflects only good taste, yet has exceptional resistance to wear and tear. Solid **Fiberesin** offers you a practically unlimited choice of wood grains, patterns, colors, designs, and special surface effects . . . even antique white Provincial. Many leading furniture manufacturers and designers use solid **Fiberesin** because furniture built with solid **Fiberesin** can be produced more profitably and quickly, does not require drastic changes in production methods, and offers so much more quality and satisfaction to the ultimate user. Whether you are thinking of fine household or institutional furniture . . . or just thinking . . . we suggest you consider solid **Fiberesin,** the solid plastic panel that speaks your language.

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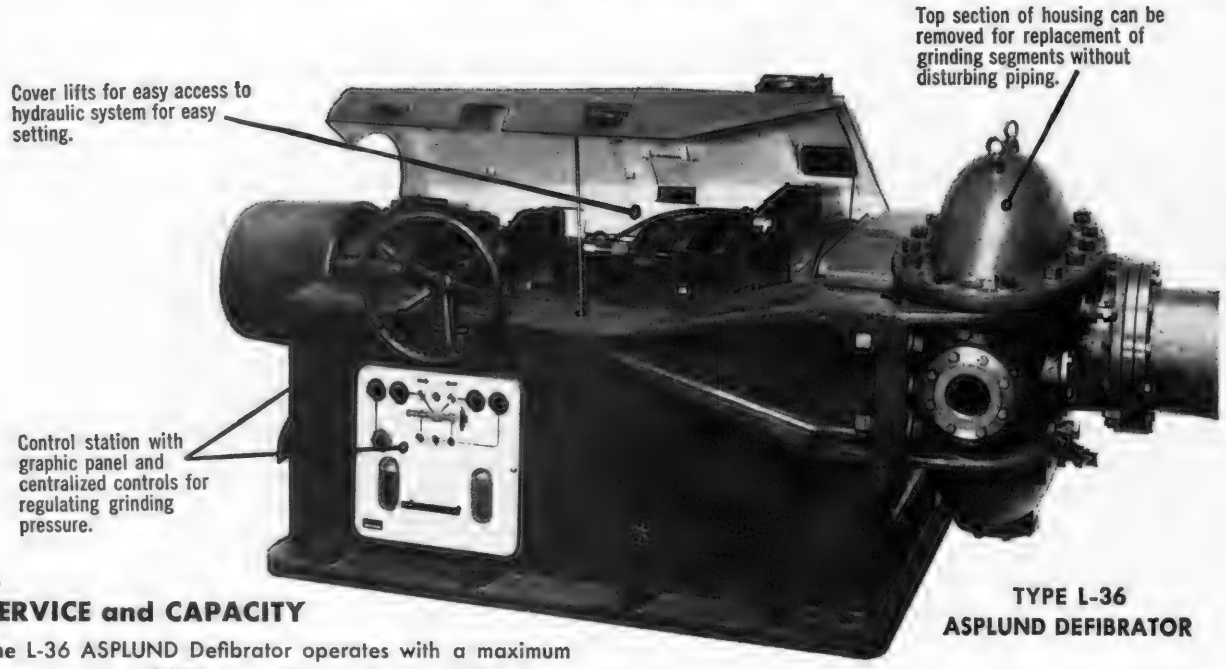
*Fiberesin meets or exceeds all pertinent commercial standards for melamine high pressure decorative laminates. Fiberesin meets all specifications and requirements of Federal Specification L-T-0041c (GSA-FSS) Type III.

FOR CONTINUOUS PULPING, THE NEW *Asplund* L-36 DEFIBRATOR

offers

- Close control of grade and uniformity of pulp
- Precise adjustments easily made with hydraulic controls
- Continuous service with low maintenance


Top section of housing can be removed for replacement of grinding segments without disturbing piping.
Cover lifts for easy access to hydraulic system for easy setting.
Control station with graphic panel and centralized controls for regulating grinding pressure.

TYPE L-36
ASPLUND DEFIBRATOR

SERVICE and CAPACITY

The L-36 ASPLUND Defibrator operates with a maximum steam pressure of 180 psi, and is used principally for producing fiber for hardboard, insulating board, and roofing felt. It is conservatively rated at 80 tons of hardboard fiber per day. It is also used for semi-chemical pulping and asphalt dispersion with capacity up to 150 tons per day. The size of the Defibrator motor in either case is between 400-600 HP.

CONSTRUCTION

Solidly built for continuous heavy duty service, with double acting thrust bearings and one radial bearing, all lubricated through a circulating oil system by means of a pumping unit with safety controls. Two 36" discs, one rotary and one stationary have replaceable segments; segment holders, housing, and top cover are all stainless steel. The shaft in the main stuffing box is protected from wear by a stellited sleeve.

RELATED EQUIPMENT

Rotary feeders, screw feeders, and digester units are available for use with existing equipment, or coordinated for use with the L-36 ASPLUND Defibrator. Size of feeders and digester units depends on the type of process, the volume to be handled, and the capacity required.

FACTS and FIGURES

When you are planning to add pulping facilities or to modernize, we will be glad to work with you in detail toward layout and equipment best suited to your requirements.

AMERICAN DEFIBRATOR, INC. CHRYSLER BUILDING NEW YORK 17, N. Y. West Coast: A. H. Lundberg Mercer Island, Washington

Session XII, Glues and Gluing, and Veneers and Plywood; P. Northcott, recorder; R. Sullivan; C. A. Herstrom; B. S .Bryant, chairman; H. M. Preusser; R. K. Stensrud.

Co-Chairmen Don Lubeck and Ralph Bescher (third and fourth from left, front row), discuss the organization of the newly-formed Treatments and Coatings Division with some of their members.

Session XI, Merchandising: G. A. Smith, recorder; C. Edgett; William Lloyd, chairman. P. R. Beattie.

Session II, Wood Preservation: H. A. Huber (standing); R. H. Bescher, chairman; Ira Hatfield, recorder.

Logging Division officers, L. N. Ericksen, past chairman; J. A. Doyle, chairman; and George Stenzel, secretary, review the year's activities.

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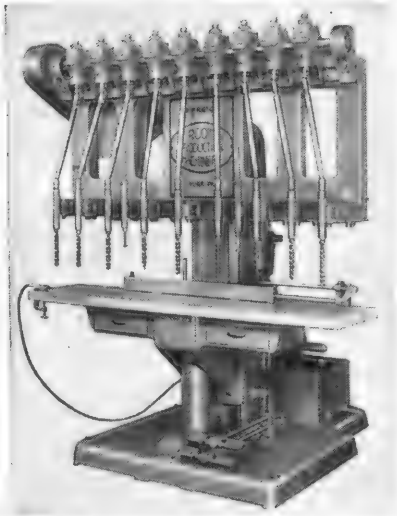
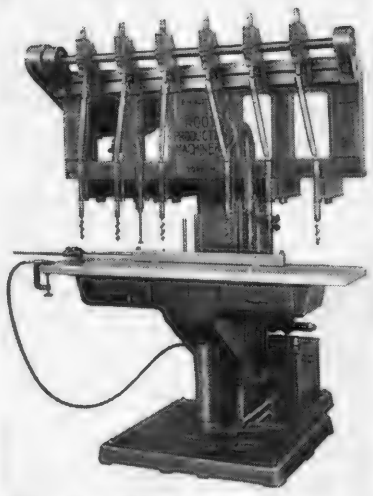
Built by Boring Machinery Specialists

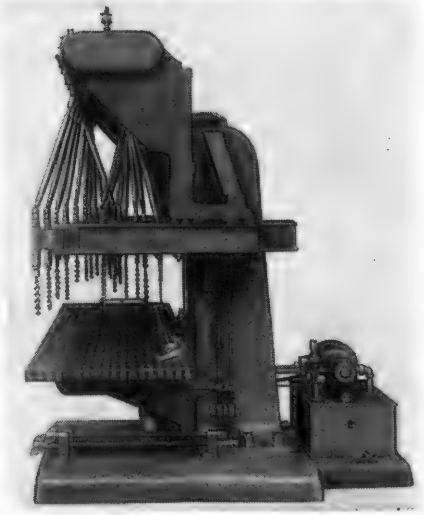
Featuring . . . HYDRAULIC FEEDS



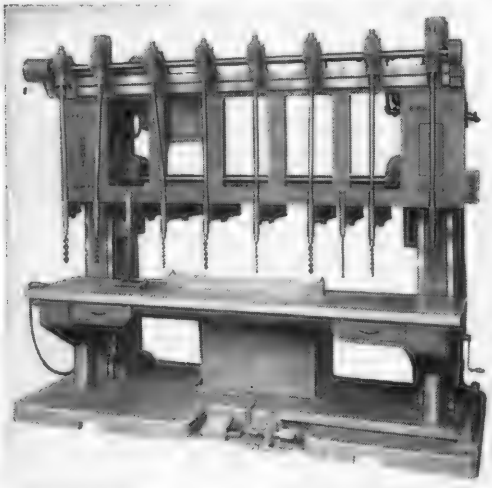
Style CH MULTIPLE BORER—General purpose borer with reserve power for heavy boring. Universal spindles provide unlimited set-ups for straight or staggered boring. Specs: Crossline spindle adj. 12"; built in 4', 5', 6' & 8' length capacities; table stroke adj. ½" to 16"; minimum spindle centers 13/16", 1-1/16" & 1-1/2".



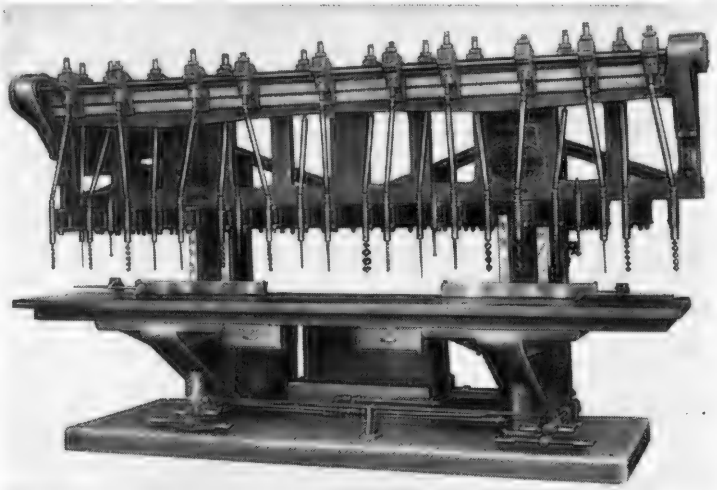
Style C311 MULTIPLE BORER—Medium size gang borer with features same as large machine, popular for parlor frames, chairs, tables and general purpose furniture boring. Specs: Crossline spindle adj. 10"; Max. boring length 4' 6"; table stroke adj. ½" to 14". Style C311-S2 same with 17" crossline spindle spread.



Style CXH MULTIPLE BORER—Parallel shafts driv two rows of spindles, boring more holes ove greater widths. Used for panels, assembled frames, etc. Universal spindles for straight o offset boring on close or extended centers. Specs Crossline spindle adj. 22"; built in 4', 6' and 8' length capacities; table stroke adj. ½" to 16".



Style CFH MULTIPLE BORER—Type with spindles feeding to stock. Features hydraulic cylinder feed both ends. Feed can be started, stopped or reversed at any point in feed or return stroke. Specs: Crossline spindle adj. 14"; boring length 8' 6" in front of columns, 6' 6" between columns; spindle stroke adj. ½" to 12"; table 14" vertically adj.



Style CCXH DOUBLE COLUMN BORER—Available with boring lengths from 10' to 24', with 22" crossline spindle adjustment, bores up to 40 holes at one stroke. Can be furnished with divided table to operate as a single unit or as two smaller, independent borers. Style CCH available with 12" crossline spindle adj.

WOODWORKING MACHINERY MANUFACTURERS ASSOCIATION

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The Division Officers discuss the new division organization at the Division Officers Executive Board Luncheon.

R. F. Blomquist gives his report at the combined business meeting of the Glues and Gluing and Veneer and Plywood Divisions.

Constitutional Amendment Legalizes Divisions

ONE OF THE HISTORIC ACHIEVEMENTS of the 14th National Meeting of the Forest Products Research Society in Montreal was to bring to climax the several years of plans and action directed toward full incorporation of the subject-matter divisions in the Society's Constitution.

Article XI

At the annual business meeting, held June 6 in the Marquette and Jolliet Rooms of the Queen Elizabeth Hotel, J. J. Allegretti, Chairman of the Constitution and By Laws Committee, moved that the Constitution be amended by adding Article XI to provide for legal recognition of the subject-matter division. The motion was seconded and passed by majority vote of the record 200-plus voting members at the meeting.

This floor action was confirmed by a majority vote of the entire membership through a mail ballot in September.

Division Review Committee

Prior to the Montreal Meeting, the Executive Board had appointed a Division Review Committee consisting of H. O. Fleischer, Arthur Muschler, S. B. Preston, Donald Saunders, R. H. Berry, and Charles Kreider.

To facilitate the work of the Committee, Messrs. Fleischer, Muschler, and Preston were appointed as a subcommittee to attempt to set forth a new Division on structure that would cover present and future subject matter interests.

The report of his sub-committee, which was adopted with some modification by the Committee, was based on these factors:

1) The major purpose of the Society is to provide a medium of exchange of technical information.

2) The membership represents the entire industry with its associated educational, research and service units, and it has a heterogeneity of interests.

3) The Society has the responsibility of providing an organization of subject-matter divisions that can accommodate the interests of each of its present and future members.

The committee felt that the product-oriented divisions had already grown to an unwieldy number and that additional groups were inevitable. They recommended, therefore, a limited number of generic process-oriented divisions that would encompass all present and conceivable future interests. Each of these process divisions would consist of sub-divisions that might or might not be product oriented.

The full report of this committee was presented by Division Coordinator Donald Saunders at the Annual Business Meeting, where the motion was made, seconded, and carried that the report be accepted.

The following lists of divisions are those recommended by the Committee, and approved, after certain, modifications by the Executive Board:

Division Structure

The Division structure as finally adopted is as follows:

Division 1: **Anatomy and Fundamental Properties,** covering such subjects as wood structure, chemical properties, physical properties, and biological properties.

Division 2: **Timber Production,** covering forestry, harvesting, transportation, woods mechanization, and forest economics.

Division 3: **Mechanical Conversion,** covering sawing, veneer cutting, machining, sanding, and fractionization (chipping, flaking, defiberating, refining).

Division 4: **Chemical Conversion,** covering derived products, pulping, and modification.

Division 5: **Particle and Fiber Processes,** covering particle board, flakeboard, pulp and paper board, ~~flakeboard~~, hardboard, molded products, and plastic laminates.

Division 6: **Glues and Gluing Processes,** covering adhesives, plywood glue lam, sandwich construction, assemblies, end and edge gluing.

Division 7: **Treatments and Coatings,** covering preservation, fire resistance, exterior finishing, interior finishing.

Division 8: **Drying,** covering kiln drying, air seasoning, veneer drying, special products (chips, particles, fibers), and moisture-use relationship.

Division 9: **Engineering,** covering mechanical properties, grades and grading, structural fastenings, engineered products (timber construction, structural sandwiches, framed construction, others).

Division 10: **Production Management,** covering materials handling, plant layout, production control, work measurements, automation, and quality control.

Division 11: **Marketing,** covering codes and legislation, product standards, packaging, distribution, and promotion.

Glues and Gluing Process To Form Six Sub-Divisions

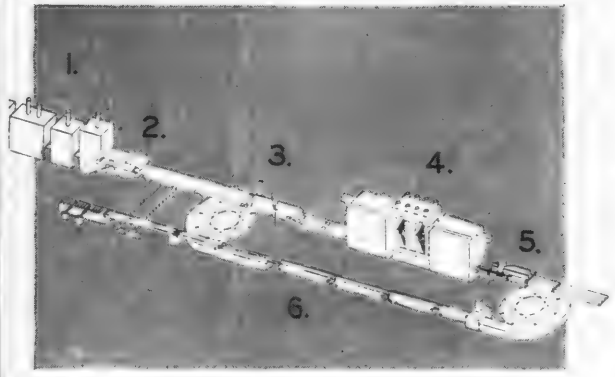
R. F. Blomquist, Chairman, U.S. Forest Products Laboratory, Madison, Wis.

I. Nominating Committee

The nominating committee composed of R. Gill, Chrm., L. Clark, A. Marra, proposed the following

BOWATER BOARD COMPANY

—new 160 million square feet per year, dry process hardboard plant relies on Washington press and forming equipment.



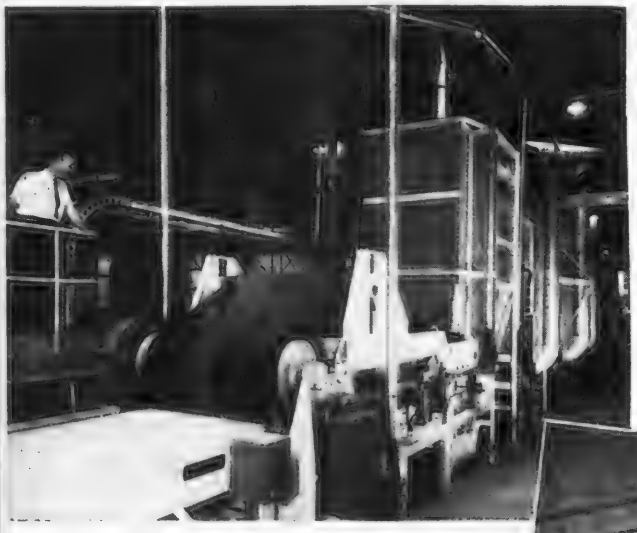
Forming line in the Bowater plant is designed for daily production of 500,000 square feet of hardboard. Washington equipment includes (1) felter, (2) precompressor, (3) cutoff and trim saws, (4) press, (5) board separator and (6) caul conveyor system.

LOCATION: Catawba, South Carolina
PLANT ENGINEERS: Bowater
PRODUCT: Smooth-both-sides "Bowater board"

The 5,274-ton, 20-opening, 56″ x 202″, simultaneous-closing Washington hot press is one of the keys to high production and efficient operation of the new Bowater plant—the largest dry-process hardboard mill in the U. S.

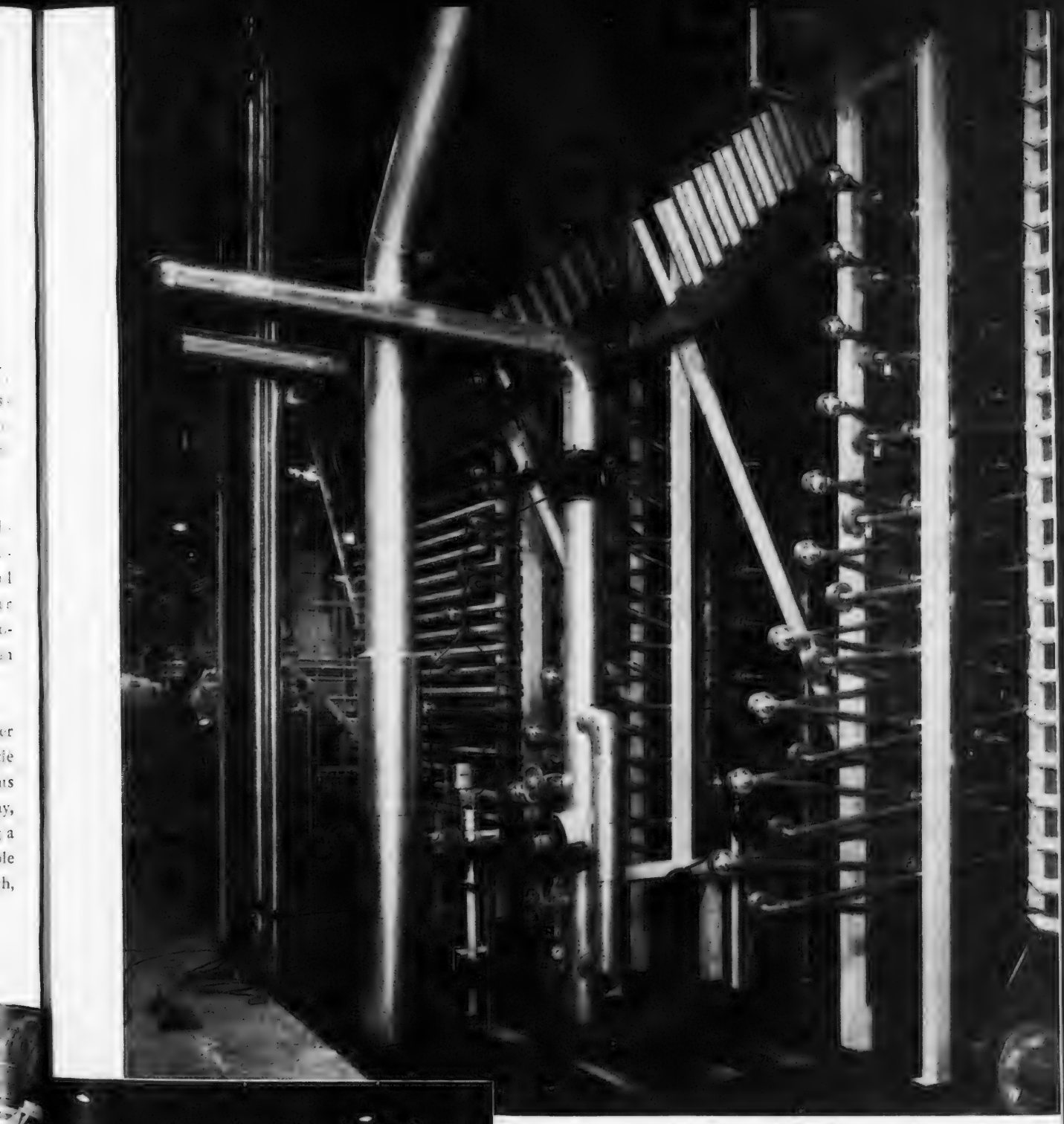
The entire forming line equipment supplied by Washington Iron Works includes felter, precompressor, mat cut-off and trim saws, board separator and circulating caul conveyor system, all custom-engineered for the Bowater installation. This equipment was designed jointly by Bowater and Washington engineers, working together from the time the new mill was in the initial planning stages.

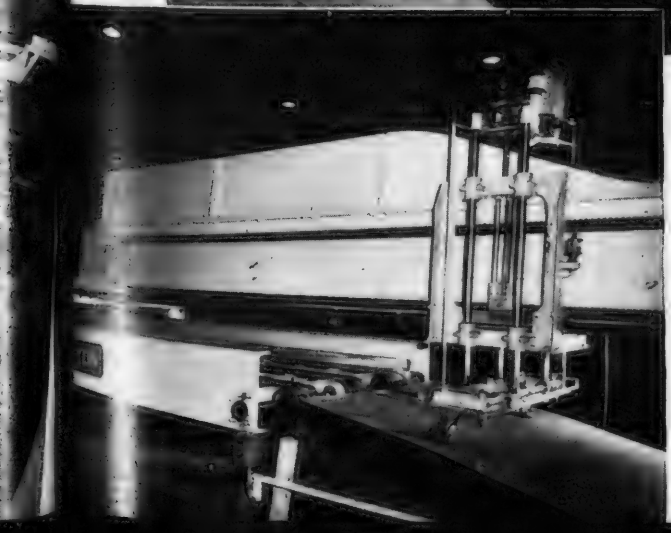
Washington press equipment is the choice of many other outstanding producers of hardboard, flakeboard, particle board and plywood. Combined capacity of board plants using Washington equipment is now over 30 acres per day, half a billion square feet per year. If you are considering a new board plant, we cordially invite your earliest possible inquiry. Washington Iron Works, 1500 Sixth Ave. South, Seattle 4, Washington.



Five oscillating nozzles delivering selected fibers permit controlled thickness, composition and density in the felting process. Shaving and precompressing follow, in the Washington unit shown above, after which the mat is cut off, trimmed and conveyed to the synchronized caul conveying system.

A unique feature of the Bowater forming line is the Washington-built caul turntable shown at right. A combination of chain and belt conveyors makes the caul system fully automatic and continuous. Washington cutoff and trim saws can be seen at the upper left. Photo on opposite page shows how boards are separated from the caul sheets after hot pressing by the Washington-built separator, using vacuum cups on a reciprocating carriage which operates while the cauls are moving.





Heart of the Bowater forming line is the 20-opening, 56" x 202" Washington hot press, above. The patented simultaneous-closing mechanism permits closing speed of 530" per minute. The press operates on a 2-1/2 minute cycle, producing 4' x 16' hardboard panels from 3/32" to 3/8" in thickness.

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WASHINGTON IRON WORKS

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HOT PLATE PRESSES • PULP BALING PRESSES
SPECIAL HYDRAULIC PRESSES • AUTOMATIC LOADERS AND UNLOADERS
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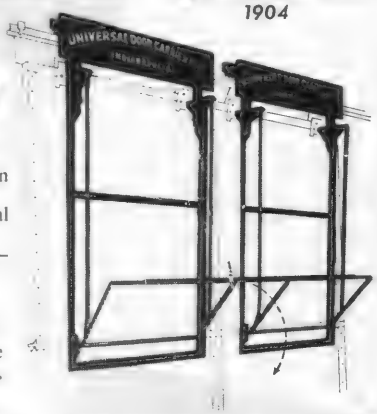

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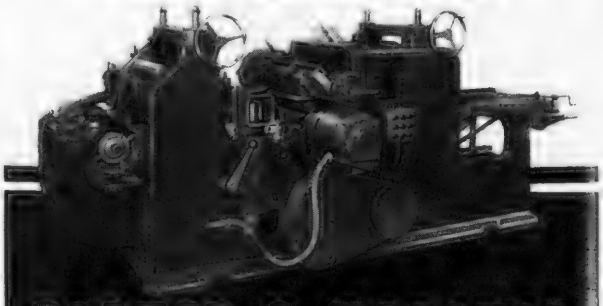
Universal **DOOR CARRIER, INC.** 1117 CORNELL INDIANAPOLIS

Specialists in Kiln Closure Equipment — Since 1904

NEWMAN

M-68

DIRECT MOTOR DRIVE



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A six roll ALL ELECTRIC medium feed machine

Feeds to 175 feet per minute. Feed gears heat treated and interchangeable. The M-68 DMD is extremely close coupled to insure ACCURATE SIZING WITH SUPERIOR FINISH

HORSEPOWER

Top Cylinder: 40 — Bottom Cylinder: 20 — Profiler: 15

Side Heads: 15 and 20 — Feed: 7½

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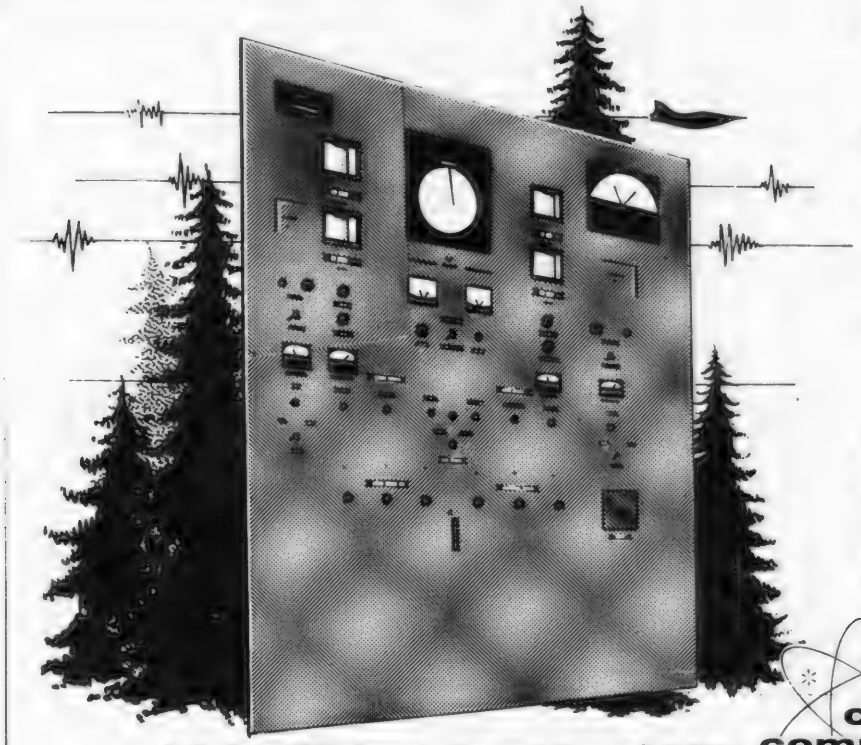
Greensboro North Carolina U.S.A.



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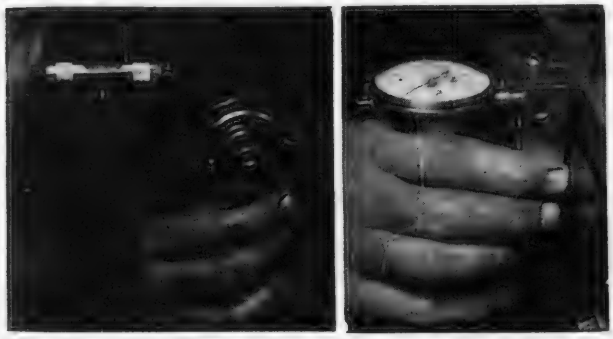

TWO NEW INSTRUMENTS, a precision angle indicator and horizontal opening indicator, eliminate "rule of thumb" methods for setting the angle of the knife and the horizontal opening between knife edge and nosebar on veneer lathe or slicer.

SINCE introducing these 2 new tools for precision cutting of veneers in January, they have been ordered and put into use in both softwood and hardwood veneer plants in every section of the U. S. and Canada — from British Columbia to South Carolina, from California to Ontario.

At a recent meeting one producer observed, "It doesn't make any difference how experienced the operator, there comes a time when he gets into trouble for some reason or other and he just can't get back. If he has some standards such as these instruments, they would help him correct his trouble."

With these instruments, even a novice can make accurate adjustments on lathe or slicer and cut good veneer consistently.

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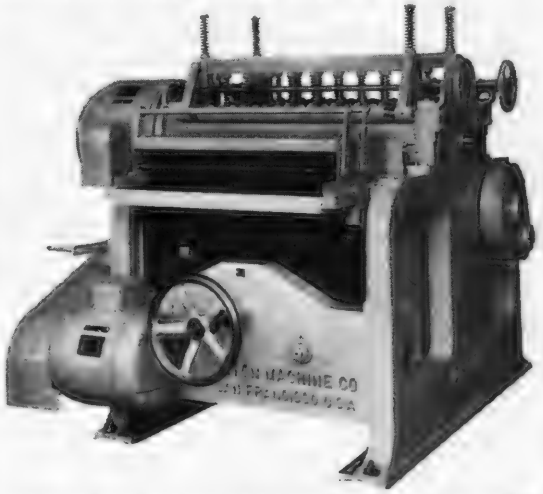
ORTON Type C, Heavy Duty, End. Bed Sgl. Surfacer.
ORTON D-1, Cabinet, Endless Bed Single Surfacer.
ORTON D-1, Gang Straight Edge Rip Saw.



ORTON D-1, GANG STRAIGHT EDGE RIP SAW

ORTON MACHINE CO.

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slate of officers for the year, 1960–1961: Chairman—R. F. Blomquist, USFP, Madison, Wisc.; Vice-Chairman—C. B. Hemming, U.S. Plywood Corp., Brewster, N.Y.; Secretary—George Meier, Haskelite Mfg. Corp., Grand Rapids, Mich. The above slate was voted in for 1 year time; Secretary casting unanimous ballot.

II. Preparation of the Annual Report

Mr. Blomquist reported that he felt that he had this matter under reasonably good control and would follow current practice of soliciting review of gluing progress from selected members, and receiving contributions from Section Representatives on the Division of Glues and Gluing. The broader the participation of members of the Division, in providing new and novel items, the better will be the future reviews.

Dr. B. S. Bryant distributed copies of a gluing bibliography for the year 1959. He will continue this service to the Division next year, as well as start a patent review on glues.

Chairman Blomquist checked with the present Veneer and Plywood Division members, particularly those who joined the new Subdivision (b) below, to make certain that this division covers matters on glues that might be pertinent to them.

Chairman Blomquist's Annual Review appeared in the February 1960 issue of the Forest Products Journal along with an appropriate bibliography.

III. New Sub-Divisions of new Division organization

The subdivisions proposed by the Committee recommending the new Division organization included:
a) Adhesives, b) Plywood, c) Glue Lam, d) Sandwich Construction, e) Assemblies, f) Edge and End Gluing.

It was generally conceded that these groups were satisfactory, at least for the present. A motion was made, seconded, and approved, that this Sub-Division classification as above be accepted and that Chairman Blomquist be authorized to appoint Sub-Division Chairmen during the coming year

IV. Louisville Program of 1961

Several suggestions were made for the 1961 program. Possible papers on "Factors Affecting Dimensional Stability of Glued Products" and "Technology of Applying Overlays to Plywood or Similar Substrates" were discussed. A motion was made, seconded and approved, to have at least 2 and possibly 3 technical sessions at the 1961 annual meeting at Louisville. Chairman Blomquist requested that suggestions on paper from members be forwarded to him as soon as possible.

Members present were:

Yves Baillargeon, Reichhold Chemicals Co., Canada Ltd., Toronto; Richard Garner, Koppers Co. Wood Pres. Div., Orville, Ohio; R. L. White, Koppers Co. Inc., Chemicals & Dyestuffs Div., Pittsburgh, Pa.; B. S. Bryant, Univ. of Wash. College of Forestry, Seattle, Wash.; Carl Trinkle, The Baldwin Piano Co., Cincinnati, Ohio; Robert Gill, Peter Cooper Corporations, Gowanda, N. Y.; Joe Patterson, Plywood Fabricator Service, Chicago, Ill.; K. D. Simmerling, Jamar Plywood Ltd., Kirkland Lake, Ont.; P. L. Northcott, F. P. L. of Canada, Vancouver, B. C.; R. W. Peterson, F. P. L. of Canada, Ottawa, Ont.; A. G. Glennie, Dominion Electrohome, Kitchener, Ont.; H. M. Preusser, American Marietta Co., Seattle, Wash.; H. A. Huber, Dow Chemical Company, Midland, Mich.; D. B. Richards, Auburn University, Auburn, Ala., D. H. Percival, Small Homes Council, University of Illinois, Carbondale, Ill.; A. J. Heeb, Formica Corp., Cincinnati, Ohio; J. B. B. Stryker, Perkins Glue Co., Kitchener, Ont.; L. E. Clark, Jr., Perkins Glue Co., Lansdale, Pa.; Sheldon Greene, Hammond Oregon Co., Chicago, Ill.; J. W. Maxwell, Borden Chemical Company, New York, N. Y.; J. R. Roberts, Consultant U. S. Gypsum Co., Chicago, Ill.; J. H. Stryker, Perkins Glue Co., Lansdale, Pa.; J. Hayward, Perkins Glue Co., High Point, N. C.; F. J. Buss, Perkins Glue Co., Rochester, Vt.; W. J. Groah, Hardwood Plywood Institute, Arlington, Va.; F. W. Herrick, Rayonier Inc., Shelton, Wash.; C. C. Booth, Borden Chemical Co., Bainbridge, N. Y.; and R. F. Blomquist, U. S. Forest Products Lab., Madison, Wis.

Drying Division To Produce Film on Wood Drying

R. S. Millett, Chairman, Canadian Forest Products Laboratories, Ottawa, Ontario.

News—Digest Subcommittee

The News-Digest Subcommittee, in co-operation with the U.S. Forest Products Laboratory has prepared and distributed a total of 86 monthly issues since April 1953, according to Chairman Ray Rietz. The USFPL can no longer continue this activity and it was suggested that steps be taken to find other means of financing, and someone else to assume the responsibility of getting out future issues, possibly by experiment stations, forest products laboratories and by dry kiln clubs.

II. Wood Drying Organization Subcommittee

Chairman E. M. Conway reported that there are now 20 active dry kiln clubs in the country, with a wide variation in programs and holding meetings. To keep the lists current, names of new officers should be sent to Ray Rietz at U.S.F.P.L.

III. Wood-Moisture Subcommittee

The subcommittee and the U.S. Forest Products Laboratory are developing plans, which will be compatible for studying the moisture content of wood in use. Plans by the subcommittee define responsibilities which include participation by dry kiln clubs and similar organizations. It was indicated that Forest Service plans for this study would soon be implemented. J. S. Bethel is Chairman.

IV. Wood-Drying Film

Chairman John Zerbe said that an outline of a proposed film has been prepared, with an estimated cost of from $10,000 to $15,000. No support has been obtained, but sources of funds are being investigated.

V. Annual Status of Wood Drying —Chairman, John McMillen

In the preparation of the 1959 report, John McMillen, Chairman said the subcommittee received and combined reports from 22 Division members and others, including overseas correspondents.

VI. Dvision Organization

Eric Ellwood reported on the meeting of Division Officers Advisory Committee and the effect which proposed amendments to the constitution would have on the divisions. Under the new organization the Division of Wood Drying will now be known as the "Drying Division". Other divisions such as Veneer and Plywood and Wood Composition Board were substantially affected. It may, therefore, be appropriate for the Drying Division to broaden in scope to cover chip, fiber and veneer drying.

A steering committee, with S. B. Preston as Chairman was appointed to study the effect of the Division reorganization and to make recommendations on (a) fields of drying which the Division should cover, (b) subject matter break-down within the Division, and (c) operation of the Division.

VII. Election of Officers

Chairman—R. S. Millett, Dept. of Northern Affairs, and National Resources, Forestry Branch, Ottawa, Canada; Vice-Chairman—E. M. Conway, Lumber Drying Specialty Company, Grand Rapids, Mich.; Past Chairman—E. L. Ellwood, University of California, Richmond, Cal.

Committee Chairmen appointed were:

News-Digest—Harvey H. Smith, Pacific Southwest Forest and Range Experiment Station, Berkeley 1, Cal.; Annual Status Report—Eric L. Ellwood, University of California Forest Products Laboratory, Richmond 4, Cal.; Wood Drying Film—J. I. Zerbe, National Lumber Manufacturers Association, Washington 6, D.C.; Wood Drying Organizations—E. F. Rasmussen, U.S. Forest Products Laboratory, Madison 5, Wis.; Wood Moisture Content Survey—J. S. Bethel, National Science Foundation, Special Projects and Science Education Section, Washington 25, D.C.

Timber Production Division Covers Forestry, Harvesting and Mechanization

J. A. Doyle, Chairman, Canadian Forest Products Laboratories, Department of Northern Affairs & Natural Resources, Ottawa, Ontario.

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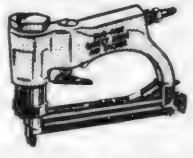

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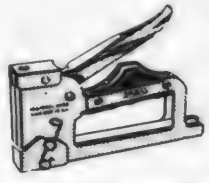

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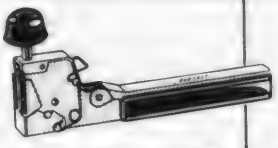

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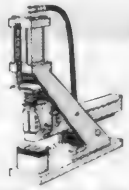

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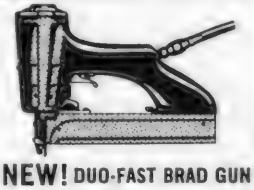

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The meeting was called to order June 8, 1960, at 3:40 p.m.

I. Division Organization

A discussion on the name of the Division resulted in agreement that Timber Harvesting most closely describes the overall description of the Division and the new name has been referred to the National Committee.

The various areas of interest to be included under the Division were brought up. The question as to whether the broad term—forestry—should be included was also discussed at some length. Forestry Relations was suggested as a substitute for the Forestry sub-division.

Mr. Doyle suggested that the prime concern of the Division should be to give technical back-stopping to the Program Committee. It was suggested that the following sub-divisions be included for the present time: Forestry Relations, Harvesting, Transportation and Woods Mechanization.

II. Election of Officers

F. C. Simmons, Chairman of the Nominating Committee, presented a report of the Nominating Committee which proposed a new slate of officers for the Division. These were: J. A. Doyle, Head, Wood Utilization Section, Forest Products Laboratories of Canada, Ottawa, Ontario, Canada, Chairman; J. W. Lehman, Chief, Forest Utilization Section, Division of Forestry Relations, Forestry Investigations Branch, Tennessee Valley Authority, Norris, Tennessee, Vice-Chairman; and W. S. O'Neill, Associate Professor of Forestry, University of Missouri, School of Forestry, Columbia, Missouri, Secretary. The slate was unanimously endorsed by those in attendance, and the Chairman was instructed to recommend its appointment to the President of the Society.

III. 1961 Meeting

Mr. Ericksen turned the duties of Chairman over to the newly-elected Chairman, J. A. Doyle, who asked for suggestions for the next national meeting which will be held in Louisville, Kentucky. W. R. Corbett suggested a paper on a rubber-tired hauling unit which is presently being used in the Crossett, Arkansas area. W. W. Calvert suggested a paper on log and tree grading. C. R. Lockard suggested a paper on logging systems—from the stump to the mill. Another suggested topic might consider forestry versus wood usage. Still another suggestion involves the experimental logging being conducted in Idaho on areas where the soil is unstable and silting of streams is a problem. T. N. Baker suggested a paper on weight scaling. Mr. Corbett suggested a paper on logging techniques which would tend to reduce logging costs in the timbered swamp areas of the south.

IV. Technical Divisions

Mr. Doyle is to contact the Section Chairmen regarding representation on the Technical Divisions to insure representation for each section.

The meeting was adjourned at 4:30 p.m.

Present were:

C. R. Lockard, Division of Forest, U. S. Forest Service, Washington, D. C.; R. H. Keen, Pulp and Paper Research Institute of Canada; T. N. Baker, St. Regis Paper Company, Jacksonville, Florida; F. C. Simmons, Northeast Forest Experiment Station, U. S. Forest Service, Upper Darby, Pennsylvania; Paul H. Lane, Pacific Northwest Forest and Range Experiment Station, U. S. Forest Service, Portland, Oregon; Wilbur R. Corbett, Corbett Lumber Company, Wilmington, North Carolina; W. A. Kraske, Columbia Cellulose Company, Ltd., Vancouver, British Columbia; W. W. Calvert, Forest Products Laboratories of Canada, Ottawa, Ontario; Robert A. Lawrence, Department of Economic Development, Augusta, Maine; J. A. Doyle, Forest Products Laboratories of Canada, Ottawa, Ontario; George Stenzel, College of Forestry, University of Washington, Seattle, Washington, and L. N. Erickson, Chief, Division of Forest Utilization Research, Pacific Southwest Forest Experiment Station, Berkeley, California, Chairman.

Mechanical Conversion Division Combines Manufacturing And Machining Groups

Paul Heller, Chairman, Pacific Pine Co., Ltd., New Westminster, B.C.

I. Division Organization

Under the new organization, the former Wood Machining Division and the Lumber Manufacturing Division are combined to form a single Mechanical Conversion Division. Two sub-divisions were established—

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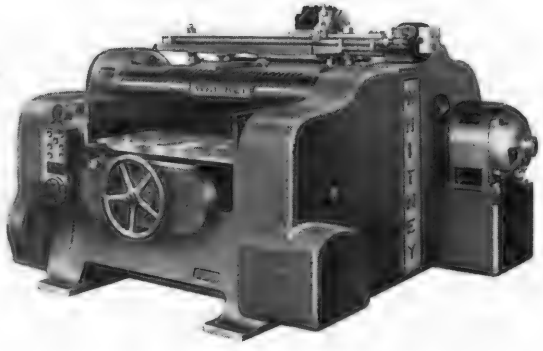

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umbering Manufacturing Sub Division and the Wood Machining Sub-Division—which will continue to arry on their former areas of activities. The names of the sub-divisions ave been taken under consideration or the coming year and will be open or discussion and action next year in ouisville.

I. Election of officers

The 1960–61 officers for the Mechanical Conversion Division elected ere: Chairman—Paul Heller, Pacific ine Co., Ltd., New Westminister, .C.; Secretary C. W. McMillin, Central Research Laboratory, American Machine & Foundry Co., Springdale, Conn.; Wood Machining Sub-Division hairman—N. C. Franz, Univ. of Michigan, Ann Arbor, Mich.; Lumber Manufacturing Sub-Division Chairman—J. K. Barrows, Jr., Barrows Manufacturing Co., Ahoskie, N.C.

The two Sub-Division Chairmen will be jointly responsible for next year's technical program.

III. Wood Machining Abstracts

A report of the activities of the Wood Machining Abstracts Committee for the 1959–1960 period was made by C. W. McMillin. A motion was made and carried to continue the work of this committee which consisted of: C. W. McMillin, Chairman; N. C. Franz; R. Hoyle, Jr.; R. W. Perkins; and L. Leney.

A new committee chairman for the 1960–1961 period will be appointed. The Executive Secretary has been requested to undertake the printing and distribution of additional copies of "Wood Machining Abstracts 1958–1959."

IV. Annual Report

Milton Mater reported that the annual report of the Lumber Manufacturing Sub-Division will be prepared for publication in the Forest Products Journal. Chairman Heller suggested that the activities of the Annual Report Committee and the Wood Machining Abstracts Committee be continued with eventual integration.

V. ASTM Wood Machining Standard

Mr. Hoyle reported that forms soliciting the comments of the old Wood Machining Division members on the proposed "Tentative Methods of Conducting Machining Tests on Wood-Base Materials" had been distributed and no comments were received at that date.

VI. Standardization Committee

The files and previous work of the Committee of Standardization of saw and knife nomenclature will be turned over to J. F. Lutz, U.S. Forest Products Laboratory, Madison, Wis. for further action.

VII. Vote of Appreciation

A vote of appreciation is extended to the program chairmen of the former Lumber Manufacturing Division and the Wood Machining Division who were responsible for the extremely worthwhile technical programs of these divisions.

The resignation of Dr. J. L. Lubkin as secretary of the Wood Machining Division is regretfully accepted and thanks is extended for his many worthwhile contributions during his association with the Forest Products Research Society.

A further vote of thanks is extended to all committee recorders, presiding chairman, committee chairman and committee members for their many contributions during the 1959–1960 period.

VIII. Steering Committee

The Steering Committee lists of the Lumber Manufacturing Sub-Division and the Wood Machining Sub-Division will be combined. This committee will be notified of changes in the structure of the organization and copies of the 1960 minutes will be forwarded.

Those recorded present were: M. J. Brisson, Forano Ltd. Montreal; C. P.

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Anatomy and Fundamental Properties Division To Provide A Forum For Basic Sciences

R. L. Youngs, Chairman, U.S. Forest Products Laboratory, Madison, Wis.

I. Election of Officers

As the first step in the organization of the new Division of Anatomy and Fundamental Properties, the following officers were elected to direct such efforts during the present year: Chairman, Robert L. Youngs, U.S. Forest Products Laboratory; Vice-Chairman, Alan A. Marra, University of Michigan; Secretary, Michael A. Taras, Southeastern Forest Experiment Station.

II. Subdivisions

No formal subdivision was made, but it is anticipated that the Division will be involved with basic work in wood structure, chemical properties of wood, physical properties of wood, and biological properties of wood. Also included in the Division's field of interest will be basic studies of the mechanical properties of wood.

III. 1961 Meeting

One of 2 technical sessions of the Division will be held at the 1961 annual meeting of the Society. A primary selection of the planning for technical sessions will be careful selection of papers with adequate time for presentation and discussion. A decision as to the number of technical sessions to plan for will be made when the types and numbers of papers available can be determined. It is recognized that the interests of this Division will relate closely to those of many other Divisions, so efforts will be made to coordinate presentations in such a way as to avoid duplication of coverage.

IV. Annual Review

Plans are under way for an annual review of progress in the areas of work covered by the Division. Because of the extremely broad scope of these basic areas, it will be necessary to limit the review to contributions in each area that may be considered as being fundamentally related to wood science and technology.

This Division should be able to make a real contribution to FPRS by drawing together and providing a forum for discussion of work in the basic wood sciences. Every effort will be made to develop a Division program that will provide for an effective contribution in this area.

Particle And Fiber Processes Division Plans Papers For Louisville Meeting

A. L. Mottet, Chairman, International Paper Co., Long Bell Division, Longview, Wash.

I. Election of Officers

H. C. L. Miller presented the nominations of A. L. Mottet, chairman, and Wayne Lewis, vice-chairman. Kjell Stordalen moved and David Haile seconded that the nominations

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be closed and the nominees be unanimously elected. Motion passed.

II. Division Organization

Mr. Lewis presented a summary of the report of the Committee on Reorganization of the Divisions. He said that the Division would now be called Particle and Fiber Products and would include such areas of interest as particle board (including flake-type board), pulp and paper board, fiberboard (insulating board and medium-density building fiberboard), hardboard, molded products, and plastic laminates.

He also pointed out that Division 3, Mechanical Conversion, with an area of interest in fractionization (chipping, flaking, defibrating, refining), Division 8, Drying Special Products, with an area of interest in chips, particles, and fibers, and other divisions had some interest to members.

Roberts added that at the present time there was considerable activity in the field of molded products both from fiber and from particle and for the next year at least, that kind of material would be included.

III. 1961 Meeting

A general floor discussion was held on plans for the division's technical program in 1961. It was generally agreed that two sessions would be preferred as the maximum. Papers suggested covered the following subjects: requirements for particle board floor tiles; problems with floor tile over various underlayment materials; specifications and limiting values for particle board; survey of European process on molded shapes; advantages and disadvantages of S1S, S2S, and air-felted hardboard; and, a panel on new equipment and techniques for production of all types of particle and fiber products.

IV. Preprints

Hamilton brought up the matter of preprints for meetings. This year there was consideration for preprints on a national basis, but it was rejected by the Executive Board. Present plans are for a ballot of the membership before the next national meeting. Hamilton asked for a show of hands of the Division of those who would like to have preprints available at the next national meeting of the Society and most of those attending desired them. Dale Turner stated that we could preprint on a Division basis if we wished.

V. Annual Report

Roberts discussed the plan he had used this year for the annual report, that he had sent out 50 inquiries for information and received 35 replies. He said the same plan would be used for this year's report unless the membership wanted something else.

The meeting was attended by: Brooks Applegate, Travis–Applegate Co., Grand Rapids, Mich.; L. C. Bratt, Stanford Research Institute, Menlo Park, Cal.; S. W. Brooks, Emerite Corp., Jackson, Miss.; F. L. Brown, Dow Chemical Company, Midland, Mich.; R. S. Burnett, Wilson & Co., Inc., Chicago, Ill.; T. J. Buss, Perkins Glue Co., Rochester, Vt.; Craig Campbell, Olin Mathieson, West Monroe, La.; J. W. Churchill, W. Va. Pulp & Paper Co., Tyrone, Pa.; L. E. Clark, Jr., Perkins Glue Co., Lansdale, Pa; J. T. Clark, W. Va. Pulp & Paper Co., Tyrone, Pa.; G. Wm. Dooege, Wabash Screen Door Co., Minneapolis, Minn.; H. M. Ely, Oregon Lumber Co., Dee, Ore.; J. F. Foley, 6358 S. Dorchester, Chicago, Ill.; D. A. Haile, Rock Island Millwork Co., Rock Island, Ill., J. Allan Hauter, Allan Products Corp., Cincinnati, Ohio; R. C. Hughes, MacMillan-Bloedel and Powell River Ltd., Vancouver, B. C.; E. Sigurd Johnson, North Carolina State College, Raleigh, N.C.; W. G. Lang, Abitibi Power & Paper, Toronto, Canada; Arno Lessheim, Hillenbrand Indus. Batesville, Ind.; W. C. Lewis, Forest Products Laboratory, Madison, Wis.; J. L. Love, Love Wood Products, Diboll, Tex.; J. W. Maxwell, Borden Chemical Co., New York, N.Y.; W. L. Meek, Minnesota & Ontario Paper Co., International Falls, Minn.; H. C. L. Miller, Miller Hofft, Inc., Richmond, Va.; Eugene Nalywajko, Protexol Corp., Kenilworth, N.J.; Richard Nelson, American Marietta, Seattle, Wash.; J. L. O'Brien, Miller Hofft, Inc., Richmond, Va.; G. E. Olson, The Dow Chemical Co.,

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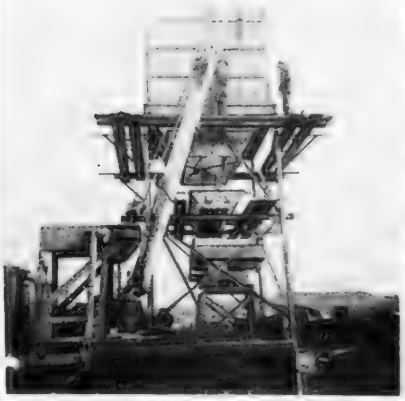

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Chemical Conversion Division Plans Two Sessions for 1961

Fifteen members of the Chemical Conversion Division, formerly Chemical Utilization Division, attended the annual business meeting in Montreal. The meeting was called to order by Vice-Chairman Fred G. Perry, in the absence of Chairman Dr. I. A. Pearl. The following is a summary of the minutes of that meeting.

I. Election of Officers

The report of the nominating committee, Dr. A. S. Gregory, Chairman, was called for as the first item of business so that the newly-elected officers could preside at this meeting. The following persons were nominated for the 1960–1961 term of office: Chairman—Fred G. Perry; Vice-Chairman—Jerome Saeman; Secretary—F. W. Herrick. There being no further nominations from the floor, the above officers were duly elected.

II. Program Committee

The Vice-Chairman of the division acts as the chairman of the program committee. Mr. Perry reported that, with the help of Mrs. Claire Canty, some 15 organizations or individuals had been contacted in the quest for papers to be presented at the 1960 annual meeting. Six papers were obtained, as were some leads for future presentations. The theme for this years' 2 technical sessions was: "The Chemical Approach to the Utilization of Wood".

III. Annual Review

I. A. Pearl, Chairman, was absent. The 1959 review appearing in the February issue of the Forest Products Journal was acclaimed as being outstanding, and the demand for reprints has again been very gratifying. It was agreed that Drs. Pearl and Rowe be asked to continue this service during the current year.

IV. Memorial Lecture

It was voted to disband this committee, since the Executive Board of the Society is now sponsoring this idea. A resolution approving of the present handling of the memorial lecture and award by the executive board was passed, with the hope that this event will be continued on an annual basis. It was also suggested that the officers of the division act as a scanning committee for candidates for the memorial lecture, especially in the fields of chemical conversion, and submit the names of candidates to the Executive Board.

V. News Release Committee

The functions of this committee were reviewed. It was agreed that the editorial staff of the Journal presently fulfill most of the original needs in this area; however, there still is an opportunity to emphasize outstanding

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work on new discoveries via short news items for release either through the Journal or press.

VI. Chemical Utilization Directory Committee

Dr. Pearl, Chairman, was not present. Efforts to compile a list of companies or institutions actively engaged in chemical conversion (utilization) research or development have been largely unsuccessful, due to reluctance on the part of industry to disclose work along this line. It was voted to drop this committee from the activities of the division for the present.

VII. Division Organization

Organizational changes in the society and changes in division names and objectives were discussed. The new name "Chemical Conversion" for this division does not limit the scope of interest as developed during the past years of division status under the old "Chemical Utilization" name. In general, the 11 new divisions are divided into interest areas through process rather than product orientation. The general concept of utilization may thus be projected through many divisions. In planning for annual or section meetings, it would be well to look ahead with the idea of developing joint programs with other divisions whenever interests or subject matter overlap.

VIII. Technical Program

On the subject of the technical program of the annual meeting, Mr. Perry announced the new policy requiring each divisional program to be completely planned 4 months in advance of the meeting, with copies of all papers in the hands of the program chairman at this time. Considerable discussion followed, the feeling being that this early planning date could not be met, it being quite difficult to get commitments for papers in any case. The subject of abstracts of papers and preprints was also discussed extensively. It was the general feeling of the group that abstracts could be as long as 400 words and include: 1) A presentation of critical data, possibly in tabular or graphical form; 2) A discussion of significant results; 3) Conclusions.

A resolution to be forwarded to the executive board was passed, reading as follows: The Chemical Conversion Division favors the publication of complete abstracts of all papers prior to the meeting. The abstract should contain significant results and summary data and conclusions drawn from the work.

The Division opposes the distribution of preprints of papers prior to the oral presentation. It favors, however, the preparation of preprints at the discretion of the authors, to be distributed only following presentation of the paper.

IX. Regional Section Activities

Mr. Perry, will appoint divisional representatives in each regional section. Such representatives may volunteer or may be selected from interest lists that have been compiled in past years. Members of the division were encouraged to promote local and national programs along the theme of chemical conversion of forest products. Regional representatives might also be of aid to the program chairman in lining up papers for future meetings.

X. 1961 Meeting

The division will again sponsor 2 technical sessions, possibly limiting the number of papers per session to 3 or, at most, 4. Various aspects regarding the presentation of papers were discussed. It was suggested that prospective authors obtain available manuals from Eastman Kodak on slide

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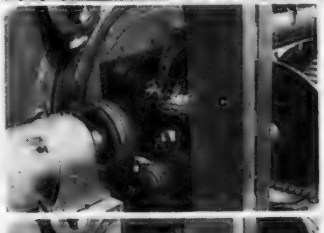

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preparation and general use of visual aids, the objective being to present data or ideas in a visible and readily understandable form. Suggestions were also made as to oral presentation in the case of summary or review papers versus specific specialized material. It was concluded that this subject merits considerable study.

The meeting was adjourned at 3:45 p.m.

Members attending the meeting were:

R. Corbett, Corbett Lbr. Co., Wilmington, N. C.; J. B. Doughty, West Virginia Pulp and Paper, Charleston, S. C.; J. Allan Hauter, Allan Products Co., Oradell, N. J.; A. S. Gregory, Weyerhaeuser, Longview, Wash.; E. G. Locke, U. S. Forest Prod. Lab., Madison 5, Wis.; T. E. Werkema, Dow Chemical Co., Midland, Mich.; Tokus Yokota, Forest Experiment Station, Meguro, Tokyo, Japan; J. M. Sayward, Vt. Bur. Indus. Res., Norwich U., Northfield, Vt.; B. A. Jayne, Institute of Technology, Washington State University, Pullman, Wash.; Everett Ellis, University of Michigan, Ann Arbor, Mich.; Mitsugu Yoshimura, Yale School of Forestry, New Haven, Conn.; J. F. Saeman, U. S. Forest Products Lab., Madison, Wis.; F. W. Herrick, Rayonier Incorporated, Shelton, Wash.; and F. G. Perry, Arthur D. Little, Inc., Cambridge, Mass.

Treatments & Coatings Division Plans '60 Theme . . . "How to Prepare and Paint Houses"

The new Treatments and Coatings Division, a combination of the Wood Finishing and Wood Preservation Divisions, plans to survey industries in both groups to determine the best way the new division can serve both interests.

At a June 7 meeting in Montreal it was tentatively planned that the new division would have a chairman and a co-chairman, one man representing the wood finishing interests and the other the preservative interests, and that each interest would also be represented by a vice-chairman who would act as program chairman.

The division made tentative plans to outline the 1961 program around the theme "How to Prepare and Paint Houses." The program would demonstrate how wood preservatives can be incorporated in the building of better homes, and it would show the requirements for the proper application of exterior house paints.

The following officers were selected for 1960–61: Donald G. Lubeck, chairman; Ralph H. Bescher, co-chairman; N. Clark Hatcher, vice-chairman—finishing; and Ira Hatfield, vice-chairman—preservation.

Publications Committee members and guests discussing the Journal are, left to right, Eric Ellwood, W. R. Smith, H. B. McKean, E. G. Locke, past chairman. R. W. Wellwood, and A. D. Syska.

Annual Report of the Publications Committee

The major effort of the Publications Committee during the past year has been the preparation of a statement of the Publication Policy of the Society, which was published in full.

During the year the President appointed Walton R. Smith, Regional Board Member, to make a study of the Forest Products Journal. Part of his assignment included working with the Publications Committee on a review of the publication policy. A statement has been prepared and approved by the Publications Committee. It was submitted to the Executive Board for their action with the recommendation it be published in the Journal.

During the past year progress was made on the International Section called "World Wide Forest Products News." R. W. Wellwood was appointed International Editor. A variety of material is now available for publication in the Journal. Agreement was reached with the Committee that only material prepared for the Journal in the country of origin would be accepted for publication.

W. I. West made a survey for the Committee of the type of articles published in the Journal during the year of 1959. After reviewing this survey the Committee recommended again that the technical articles in each issue remain the same but that an increase in the budget be requested which may permit inclusion of more semitechnical articles. One problem, of course, remains which largely controls the type of articles published. It is the source of the articles which are primarily from National and Sectional meetings. However, a sizeable number of contributed papers, which are generally research papers, have been received during the past year. This number will increase as the time between submission of papers and the publication time is decreased. In order to make this possible the Committee has recommended to the Editor that he instruct the reviewers to be more critical of the papers recommended for publication.

The Committee, at its meeting in Montreal, recommended the publication of notes and short papers as suggested by J. B. Huffman. Another recommendation was that the booklet "How to Write for FPRS" be revised during the coming year.

Publications Committee Named

Dr. H. O. Fleischer has been appointed Chairman of the Publication Committee by Society President R. H. Berry. Dr. Fleischer replaces Dr. E. G. Locke, who held the chairmanship for several years.

Other members of the committee are: A. D. Syska, E. A. Behr, J. B. Huffman, D. L. Brink, W. I. West, R. W. Wellwood, and H. B. McKean.

Retiring members of the committee deserve a vote of thanks for service rendered. Besides Dr. Locke, Past Chairman, they include: R. F. West, S. B. Preston, I. H. Isenberg, and F. F. Wangaard.

FPRS Executive, Section, and Division Officers

WITH A MEMBERSHIP OF OVER 4100 persons as this Yearbook goes to press, the national work of FPRS is administered by an elected Executive Board comprised of four officers and six regional board members. The sectional, regional, and committee work is governed by more than 300 persons.

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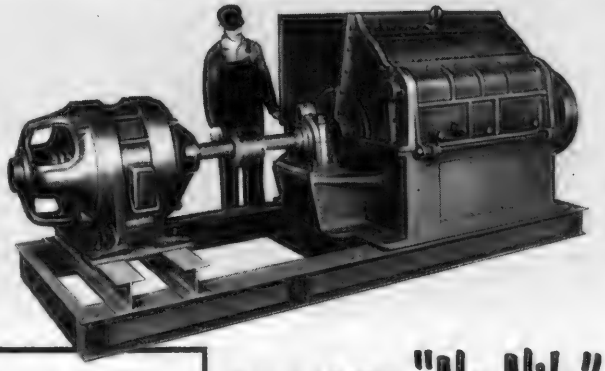

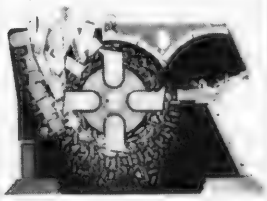

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Karl Bollerslev, (Boise-Cascade Corp.) 4913 Hillcrest, Boise, Idaho.

Syracuse to Hold Hardwood Grading Course

The State University College of Forestry at Syracuse University, Syracuse, N.Y. will again conduct its annual Hardwood Lumber Grading Short Course Oct. 31–Nov. 4 at its main campus in Syracuse, recently announced Dr. Hardy L. Shirley, dean of the College of Forestry. Lillard Nicely, nationally-known hardwood lumber grading authority and Director Emeritus of the National Hardwood Lumber Association's Grading School at Memphis, Tenn., will conduct the short course this year. Course coordinator will be Prof. Russell C. Decker who is in charge of the college's service-to-industry program.

Purpose of the five-day short course is to provide the latest data and techniques to sawmill operators, wholesalers and wood working plant personnel. Also included will be a thorough study and discussion of the rules as found in the "National Hardwood Lumber Rule Book."

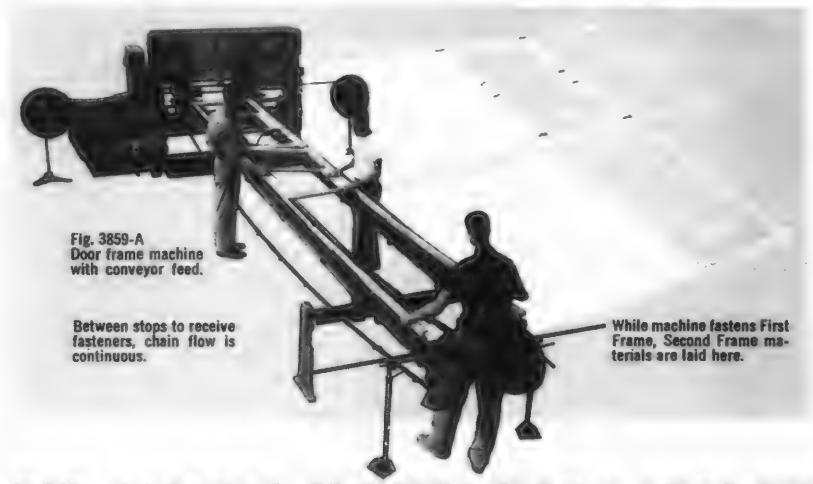
Fig. 3859-A
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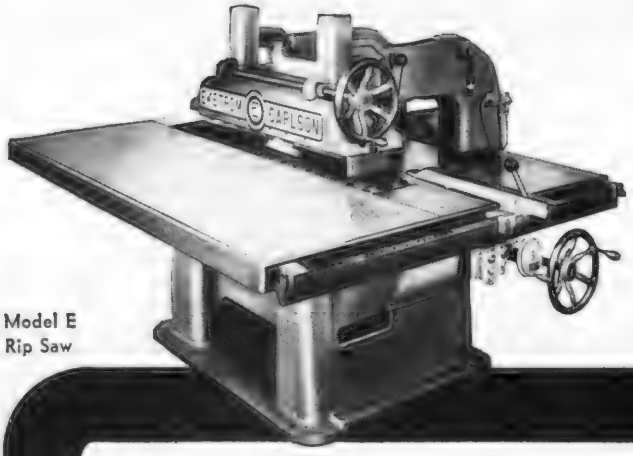

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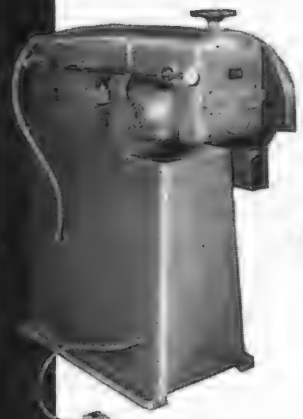

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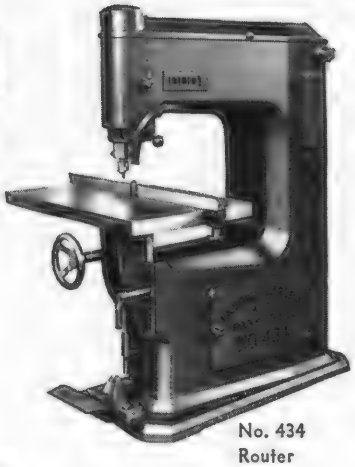

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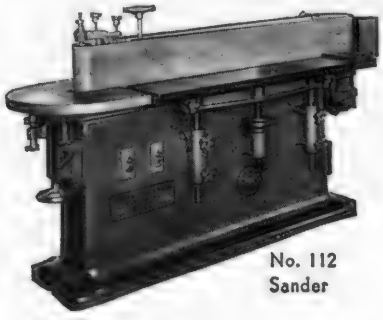

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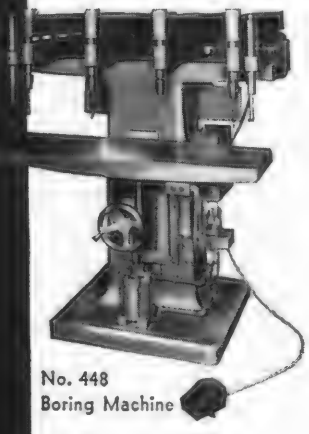

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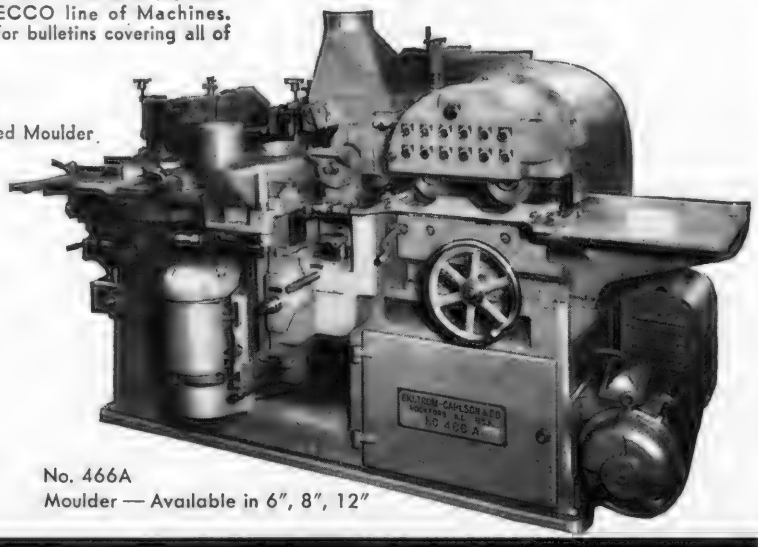

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FPRS FOREST PRODUCTS JOURNAL
VOL. X, NO. 10
OCTOBER, 1960

NEW USES FOR WOOD FLOUR IN

Rigid Polyurethane Foams[1]

Fig. 1.—Photomicrographs of wood flour used in these tests: The material is hammermilled Eastern white pine (grade 139) at 100–200 mesh, which is in a range of 147–174 microns. The flour possesses some fibrous structure and is quite uniform.

JOSEPH SHULMAN AND BURTON L. WILNER

Arthur D. Little, Inc., Cambridge, Mass., and Wilner Wood Products Co., Norway, Maine

A new concept in the pulp, paper, and chemistry industries is shifting emphasis from wood flour as a filler material to wood flour as a highly desirable raw material ripe for extensive research and development. It can be reacted with polyurethanes to produce a rigid, foamed-in-place structure for use in acoustical and thermal insulation, boats, packaging materials, and sandwich construction.

IT IS BECOMING INCREASINGLY APPARENT that both the forest products and the pulp and paper industries must reduce the cost of wood raw material charged to the process, since this contributes significantly to the cost of the final product. One way to accomplish this is to better utilize the wood raw material. For example, several companies are currently producing wood flour, both hardwood and soft, from lumber residues, and they sell it to manufacturers of plastics, explosives, rubber, and linoleum. Wood flour is actually replacing fibrous materials, such as asbestos.

One company that has developed a well-organized program of utilizing their raw materials is Wilner Wood Products of Norway, Maine. Wilner manufactures wooden heels and processes solid wood residue into pulp chips. Under their program, Wilner produces several grades of wood flour combining undersized chips from pulpwood with sawdust and shavings. And they go one step further: bark from all these operations is burned for fuel, providing steam for drying lumber and residue and providing heat for the plant.

Before beginning a more detailed discussion of polyurethanes, I would like to note several more facts about wood flour. First, it is wood which has been finely ground by either a wet or dry grinding process. Some years ago, when wood flour was used for roofing, fur cleaning, and linoleum, it was graded only on the basis of particle size and species of wood; but today, with broader uses developed for it, more rigid controls are maintained. A modern wood flour mill can meet rather exacting specifications with regard to density, specific gravity, absorption, abrasiveness, moisture control and even color. For example, both bulk density and specific gravity are important where specific weight characteristics and reproducibility are required, such as in a bowling ball core.

Absorption and bulk are both extremely important characteristics of wood flour in the manufacture of nitroglycerine explosives and cleaning compounds.

Uniformity of color is important in light colored molding compounds; therefore, good quality control must be maintained in the selection of wood for different batches of wood flour.

Moisture content of wood flour must be kept uniform so that molding

[1] Presented at Session IV, Chemical Utilization, FPRS 14th Annual Meeting, June 6, 1960 in Montreal, Canada; revised for publication August 26.

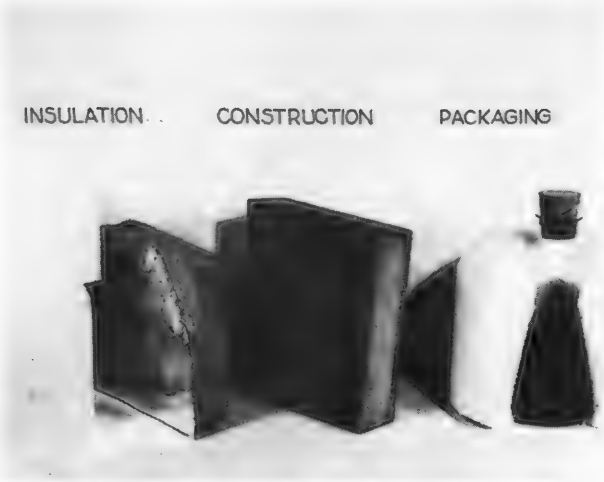

Fig. 2.—Three applications of wood flour-urethane foams.

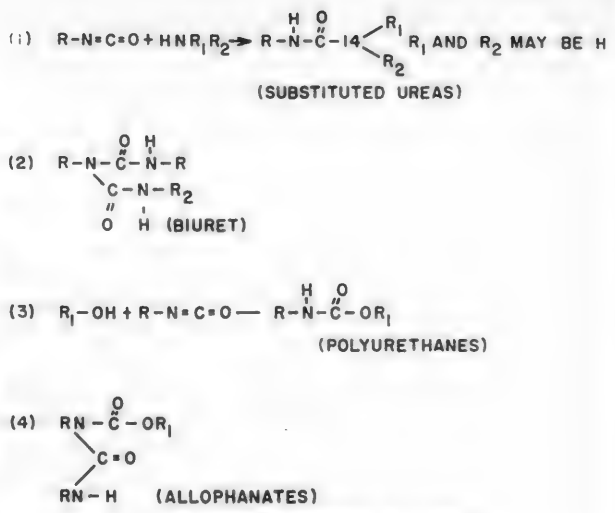
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Fig. 4.—Four polyurethane reactions.

cycles will not vary. This is also important in molding compounds where an excess of moisture must be avoided to prevent gassing and blistering. Acid characteristics and pH are also of major importance in urea molding compounds. This improved control over raw material allows a producer of phenolic molding compounds to enjoy much wider latitude, and all with one resin. He can vary the specific gravity, the degree of flow, and the texture and color of the surface.

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Many people, in both the pulp and paper industries and in the chemical industry as well, are beginning to realize that this new concept of using wood flour in the manufacture of plastics will shift the emphasis away from wood flour as a filler to wood flour as a highly desirable raw material—a raw material that is ripe for extensive research and development, and we hardly need point out that the full utilization of this former "waste" product will enable the several paper and wood industries to reduce costs significantly.

Fig. 3.—Relative decrease in density obtained by adding 10 percent wood flour to a standard foaming resin.

The idea of a wood flour-polyurethane foam was an interesting possibility because it suggested the cost-reducing advantage of using wood floor as a chemical contributor. Research on these foams is still at a relatively high level, offering the advantage of introducing wood flour into the picture early enough to take advantage of new developments.

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With the choice of appropriate new materials, resins, and techniques, a broad range of rigid cellular products will be available to meet a diversity of new markets: acoustical and thermo insulation, packaging and buoyancy materials, structural materials, laminates, sandwich structures, radomes, and other engineering products. The use of wood flour in new urethane systems may disclose added advantages, such as heat resistance and other physical properties which we are not yet aware of.

Although foamed products vary from being extremely rigid to very flexible, this study is concerned principally with rigid foams. The uses for rigid polyurethane foam resins are currently increasing, principally because they can be foamed in place. This advantage eliminates the need for expensive mixing and metering equipment, and it also provides a definite advantage over other types of resin foams that require expensive foaming machines.

The market for rigid urethane foam resins has, however, been limited because of cost; a reduction in the price of the resin compound should result in increased sales. The use of wood flour in polyurethane foams should not only reduce the cost of the compound but it should also develop a new sales opportunity for wood flour.

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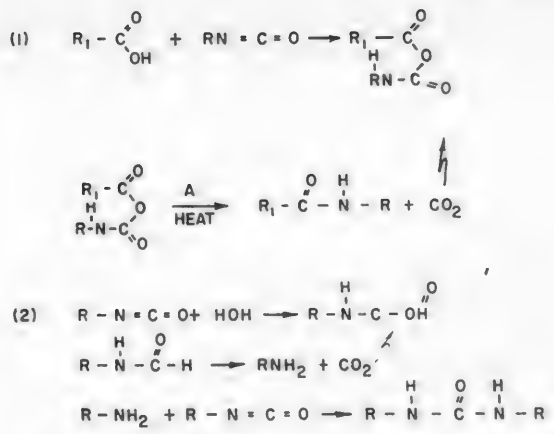
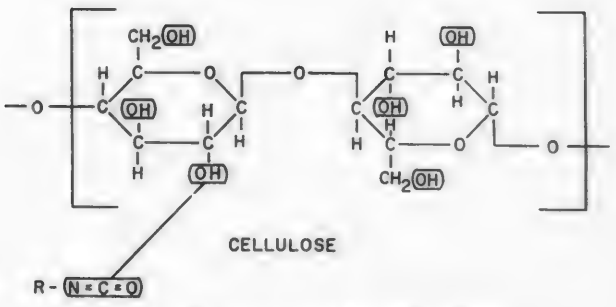


Fig. 5.—Polyurethane reactions in the production of foams.



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Reaction B: A reaction between the diisocyanate and water causing formation of carbon dioxide gas bubbles that blow up the foam. This same reaction also increases the molecular weight of the polymer. The products of this reaction are gaseous carbon dioxide and an amine. The amine will further react with the diisocyanate.

Reaction C: A minor third reaction between carboxyl groups, present in the polyester resins, and the diisocyanate also produces carbon dioxide gas and provides an additional increase in the molecular weight of the foamed polymer. The products of this reaction are gaseous carbon dioxide and an amine. In most of our work we have used a prepolymer resin that is an intermediate reaction product of a polyester with an excess of diisocyanate, which may be later mixed with the rest of the ingredients in the formulation. The prepolymers are relatively stable and may be stored for several weeks or even months prior to use.

In our preliminary evaluation of wood flour-polyurethane combinations, we selected a standard two-component system based on a urethane prepolymer. The wood flour was Wilner's Grade No. 139 Eastern white pine, photomicrographs of which are shown in Figure 1. The wood flour was added to the polyester and the prepolymer was added to this mixture, stirred, poured, and allowed to foam in place. On visual examination, the cell structure of these modified foams was uniform and unbroken, with a good skin covering and no loss in adhesion to materials such as paper, plywood, phenolic laminates, metal, and vinyl. The wood flour foams also showed a decrease in density over the control. The use of wood flour in these rigid foams appears to represent a substantial cost reduction because: 1) the density of the foam decreased appreciably; and 2) the cost per total unexpanded urethane resin composition had been decreased by addition of the wood flour (e.g., 10 per cent wood flour @ 2¢/lb replaced a $1/lb resin—a cost reduction of 10 per cent).

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Density Comparisons

Figure 3 shows the relative decrease in density that may be obtained by the addition of approximately 10 per cent wood flour to a standard polyurethane prepolymer foaming resin. On the left is a material prepared from standard commercial, 4-pound-density, rigid resin produced by the BB Chemical Company, Cambridge, Mass. On the right is a foam prepared with 90 parts of the same resin and 10 parts wood flour. The density of the control is 4.33 pounds per cubic foot. The addition of wood flour has produced a density of 3.17 pounds per cubic foot.

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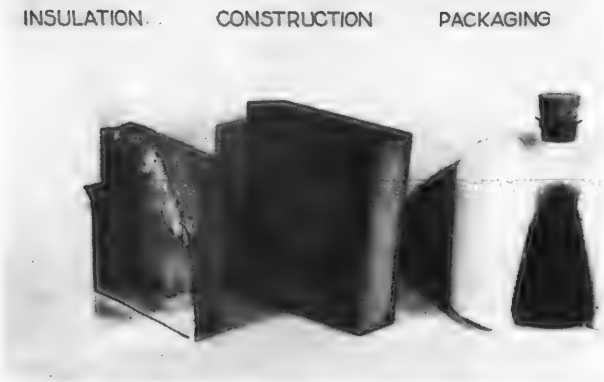

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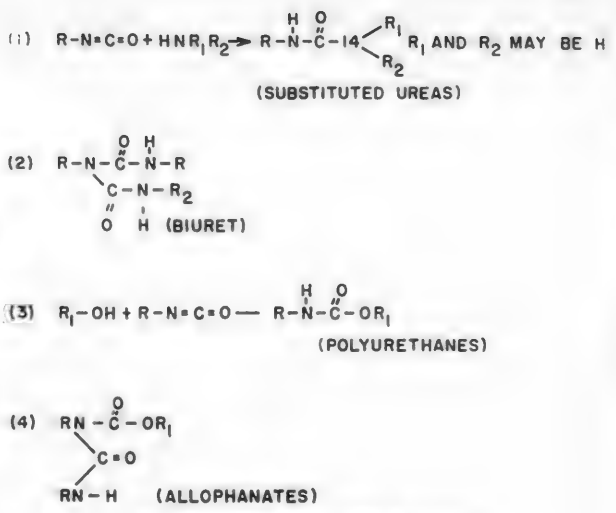
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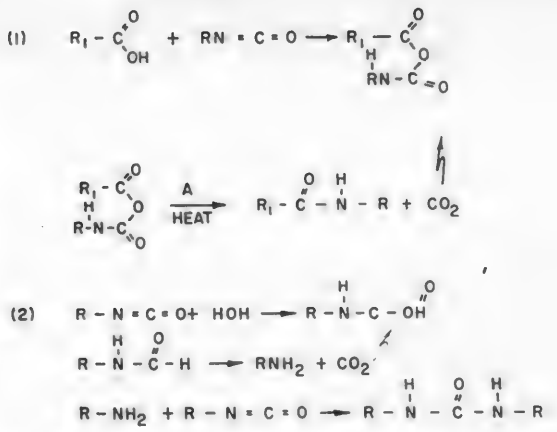

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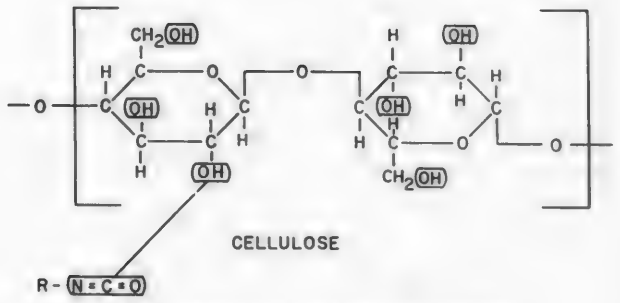

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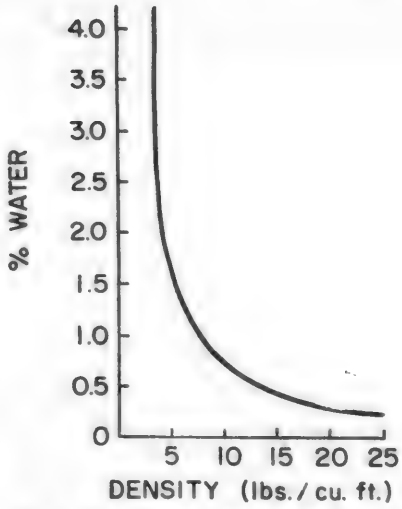

Fig. 7.—Density versus percentage of water in a polyurethane resin.

biuret and this may be observed in Reaction No. 2.

In Reaction No. 3, the reaction of hydroxyl groups with isocyanate produces urethane, the most important reaction from our standpoint. This equation illustrates the simple reaction of mono-functional components. This is a simple addition process and, when extended to functional or poly-functional chemical groups, provides a direct route to polymers.

In the case of the polyurethanes, the hydrogens on the nitrogen atoms of the urethane groups are capable of reacting with more isocyanates to form allophanates as illustrated in Figure 4, Reaction No. 4. This is a possible means of introducing cross-linking to the polyurethanes.

Reactions to Produce Foams

Figure 5 shows two polyurethane reactions in the production of foams. The reaction of stoichiometric amounts of hydroxyl containing polyesters and isocyanates form long chain polyurethanes. The addition of more diisocyanate and carboxylic acids produces carbon dioxide as illustrated in Reaction No. 1.

Reaction No. 2 is that between water and isocyanate in which water, an ingredient of a two-component foaming resin, adds to the isocyanate group to form carbamic acid. Being unstable, the latter decomposes to the corresponding amine and carbon dioxide. The amine reacts with another isocyanate group to form a symmetrical urea. Water reacts with two equivalents of isocyanate. With polyisocyanates, the reactions produce polymeric materials which are infusable and insoluble. For simplicity, we have just illustrated the reaction of a mono-functional isocyanate. In our standard rigid foaming reactions, there are several reactions taking place at the same time; since the reaction products are catalysts for the reaction itself, the reaction of polyester and diisocyanate is quite complex.

	URETHANE RESIN WITH 10% WOOD FLOUR	STRAIGHT URETHANE (CONTROL)
DENSITY (lb./cu. ft.)	3.17	4.33
TENSILE STRENGTH, (PSI)	76	138
COMPRESSIVE STRENGTH (PSI)	97	274

WOOD FLOUR FILLED SAMPLE COMPARED TO CONTROL

27% DECREASE IN DENSITY
45% DECREASE IN TENSILE STRENGTH
65% DECREASE IN COMPRESSIVE STRENGTH

Fig. 8.—Comparative data obtained on urethane resin with 10 percent wood flour and a straight urethane control.

Reaction of Wood Flour with Urethanes

In adding wood flour to the polyurethane resin, we believe that wood flour serves as more than just an inert filler. It was explained previously that the isocyanate has a high degree of reactivity with materials containing active hydrogen, and wood flour with about 60 per cent cellulose has several points of hydroxyl reactivity. It is justified to assume, therefore, that the wood flour actually takes part in the reaction and becomes an integral part of the polymer chain, as shown in Figure 6.

Figure 7 is a plot of the density versus percentage of water in a polyurethane resin. In general, the density of urethane foams is related to the amount of water; the higher the moisture, the lower the density. It will be noted that in the higher density range, the dependence of density on water is quite acute. However, there appears to be a limiting low density factor which makes the addition of water useless. In order to determine whether residual moisture in the wood flour was actually resulting in the low densities, we incorporated into the resin, wood flour dried over phosphorus pentoxide. Densities of 3.71 pounds per cubic foot for this material and 3.17 pounds per cubic foot for the undried material were obtained, which indicates that some foaming was also due to the adsorption and adsorption of water in the wood flour. The densities of even these materials, however, were lower than those of the controls. There is good reason to believe that the decreased densities may be attributed to additional reactions taking place between the components of the wood flour and the urethane.

Figure 8 illustrates some of the physical data obtained on a standard 4-pound-density, rigid foam and the same resin with 10 per cent wood flour. Both samples were mixed and cast in our laboratory under similar conditions. It may be observed that a highly desirable reduction in density has been obtained, from 4.33 pounds per cubic foot to 3.17 pounds per cubic foot.

The tensile strength is likewise reduced from 138 to 76 pounds psi, and the compression strength is lowered from 274 to 97 psi. Basically this is a 27 per cent decrease in density, 45 per cent decrease in tensile strength, and a 65 per cent decrease in compression strength. However, these comparisons are made on samples of two different densities and it would be expected that the tensile and compression strengths would be lower with lower density foams. Comparisons are now being made between foams of similar density.

Conclusion

In conclusion, the results of our preliminary work indicates that wood flour can be successfully added to urethane foaming resins to provide materials of decreased density and lower cost. Optimum properties may be obtained by tailoring polyurethane resins to the use of wood flour. We realize that for some applications there are many problems such as limiting viscosity, residual moisture, and fire retarding properties yet to be overcome. However, the surface has only been scratched and the adaptability of new resins to wood flour may solve these problems and open new markets for low-cost, pour-in-place foams made with wood flour.

TEST DATA AS A GUIDE FOR

Preservative Specifications[1]

H. A. HUBER, G. E. OLSON, AND R. M. GOOCH

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Case histories of annual tests of preservative retention, comparisons of oil carriers, and comparisons of preservative mixtures are used to show how specifications can be improved and how a well done "results specifications" will benefit the user of treated wood.

STAKE SPECIMENS being examined by co-author Ralph Gooch and an unidentified colleague on test plot maintained by Dow Chemical Co. at Bogalusa, La.

A PRODUCT OF THE TREATING INdustry, such as a pole, bridge stringer or crosstie that fails to give service is not only a threat to safety and life but to the integrity of the treater and indirectly to the customer. In spite of a splendid record in the past, treated wood has often failed to do the job it was given to do. To some extent, the failure could be attributed to the characteristics of the wood itself. A product of nature, wood is variable; each wood item is different from the one that went before. Thus, such things as differences in moisture content, geographical origin, species density, and heartwood—sapwood ratio are some of the many variables which can cause important variations in the results of treatment.

Industry specifications, developed cooperatively by treaters, users, and preservative suppliers, over a long period of time have contributed toward assuring a good treated product with long life expectancy. The specifications that have been developed are used throughout the world. To a large degree, these specifications take into account the many treating variables, and they yield fine serviceable products. The effort to produce a better end product is continuing; wood preservative men are working toward even better specifications. The prime example of this long and excellent effort is the "Manual of Recommended Practice" (1) of the American Wood Preservers Association.

It has been demonstrated that plant instrument readings do not always agree with the actual amount of preservative retained by the wood as determined by sampling and analyses. (2) If the actual amount is less than that indicated by plant instrument readings, the effectiveness which the customer expects from the treatment can be considerably reduced.

A new kind of specification, referred to as "results specifications," is being accepted and used by a growing list of users of treated wood. The exact amount of preservative required in the wood and the depth of penetration are spelled out. Inspection and analyses are made immediately after treatment on a statistical basis. This concept is not new to wood preservation since penetration requirements based on actual measurement of borings from treated wood have long been an integral part of nearly all specifications for treated wood. The advent of pentachlorophenol and the relative ease of analysis of this preservative, however, have enabled authorities to view preservative retention in the same light as preservative penetration. A large communications system was a leader in applying results specifications to their retention requirements for pressure-treated Southern pine and Douglas-fir poles. A stated amount of pentachlorophenol was required to be present in the wood as determined by chemical analyses.

Producers of Western red cedar poles had, prior to this significant development, long recognized the value of chemical analyses, and they have used it as a quality control device with respect to the thermal treatment of Western red cedar poles. This approach has proved so popular that it is now written into the specifications for all Western species of wood by the Edison Electric Institute, and definite retentions of pentachlorophenol, as determined by chemical analyses, are required.

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[1] Presented at Session II, Wood Preservation, FPRS 14th Annual Meeting, June 6, 1960 in Montreal Canada; revised for publication August 18, 1960.

Table 1.—SERVICEABILITY OF TEST STAKES AFTER 9 YEARS OF FIELD EXPOSURE

Treatment	Threshold[4] Unweathered lb./cu. ft.	Threshold[4] Weathered lb./cu. ft.	Lake Jackson, Tex. % Serviceability	Bogalusa, La. % Serviceability
20%[1] 201-E[2]–80% Seguro[3] (1% Penta)	>33.0	>34.0	0	4
40% 201-E –60% Seguro (2% Penta)	17.0	17.5	0	43
60% 201-E –40% Seguro (3% Penta)	6.2	6.5	37	69
80% 201-E –20% Seguro (4% Penta)	4.0	4.1	39	74
100% 201-E (5% Penta)	2.0	2.2	51	74
20% Creosote–80% Seguro	>34.0	>35.0	0	13
40% Creosote–60% Seguro	30.0	>33.0	0	8
60% Creosote–40% Seguro	15.5	20.0	11	42
80% Creosote–20% Seguro	10.0	13.0	22	49
100% Creosote	6.4	8.1	33	58
60% Creosote–40% Coal Tar	6.5	8.2	33	51
101-E oil	>38.0	----	36	63
Seguro oil	>32.0	----	0	0
Untreated control[5]			0	0

[1]Indicates percent by volume.
[2]201-E is 101-E oil containing 5% pentachlorophenol; IBP–536° F.; 50% 680° F.; 85%–752° F.
[3]Seguro petroleum is a commercially used oil for blending with creosote for crosstie treatment.
[4]From Duncan and Richards (8).
[5]Average service life of one year.

For several years, the treating industry, the preservative manufacturers, and the users of treated products have been conducting tests on various preservatives, oil carriers, retention requirements and other variables affecting service life of treated wood. These test data can be extremely valuable in the development of wood preservative specifications.

Specifications Based on Test Data

An historical example of the influence of test data on wood preservative specifications is evident in the work of F. J. Meyer and R. M. Gooch. (3) Their experimental work with treated wood stakes exposed to severe conditions of decay and termites shows the effect of the oil carrier on the performance of pentachlorophenol as a wood preservative. Quoting from their conclusions: "The distillation range of oils used as pentachlorophenol carriers is an important factor in the performance of the treated wood in ground contact exposure. In general, the higher the distillation range of the solvent, the better the performance of the treated wood."

To a large degree, this work pointed the way toward the requirement that the "heavy solvent" section of American Wood Preservers' Association Specification P-9 be used with pentachlorophenol. Thus, AWPA Specification C1–58 reads in part as follows:

> "Unless otherwise specified the concentration of pentachlorophenol in the treating solution shall be between 4.5 and 5.5 percent by weight; the petroleum used shall meet the requirements of Standard P–9 for heavy solvent."(1)

Another series of investigations suggested the possibility of less than the accepted 5 percent pentachlorophenol concentration in use with a very high distilling oil carrier. This work by Olson, Meyer and Gooch, (4) included soil block testing, stake tests, and post size tests. The data were applied to crosstie treatment and supported the conclusion "that the pentachlorophenol concentration can be adjusted from the traditional 5 percent to a more realistic concentration in line with the past practice and economics dictated in the treatment of crossties and still maintain a high degree of effectiveness."

These data, coupled with the excellent serviceability of 5 percent pentachlorophenol, led to the use and specification of a 3 percent pentachlorophenol solution for the crosstie treatment for one of the leading railroads on the North American Continent. Continuation of some of the tests leading up to this decision maintains the soundness of the move. Table I repeats the data presented by Olson, Meyer and Gooch (4), with added data on the condition of the stakes after 2 additional years of exposure, thus bringing the total to 9 years.

Returning to results specifications for the retention of preservative in items such as poles, we would again like to point to the pioneer specification that required a fixed retention of pentachlorophenol to be determined by analyses in a specified section of borings taken from treated poles. This specification was carefully based on a vast amount of test data, excellently summarized by R. H. Colley in a monograph entitled "The Evaluation of Wood Preservatives". (5) We would like to quote from the conclusions which he draws: "The soil block development may soon make it possible to reach approximately the ideal in which the long-time service tests of treated material in line will confirm the Laboratories' rapid test results with respect to preservative requirements. Coupled with results-type requirements (wherein the end product—not the steps of manufacture are defined) viz., (a) retention in the wood (b) penetration and (c) cleanliness, there will be even better assurance than at present of the quality performance always expected under Bell System specifications."

Service results of a group of 202 penta-treated Southern yellow pine poles were reported by W. N. Ferris in the March 1959 issue of Electrical World. (6) After 17 years of service, careful inspection revealed all the poles to be in sound condition. Mr. Ferris reported that chemical analyses revealed the penta concentrations 7, 10, and 15 years after treatment were still above the level which promises long additional life. Initial analyses were not made before installation of the poles since they were not purchased under results specifications; however, each pole was checked for penetration immediately after treatment. The analytical sampling noted during service life, the excellent condition of the poles, and the high level of penta retention provide a sound basis for writing result specifications with assurance of long service life.

Using the analytical information collected from Wisconsin Power and Light Company poles (9), a computer plotted the slope of penta change per year for each pole by successive analyses at the first ½ inch above and below the ground line. The regression lines for each pole were averaged on the computer for the entire group of poles to give a slope of penta content for the first ½ inch above and below the ground line. The initial starting point for these poles was the average analysis at the 10-year mark. The lines were projected beyond the date of the last analysis. Also, because of the relatively few plotted points, straight lines in Figure 1 were based on the method of least squares.

Using the analytical data from the results specifications as the initial point, it would be possible to predict

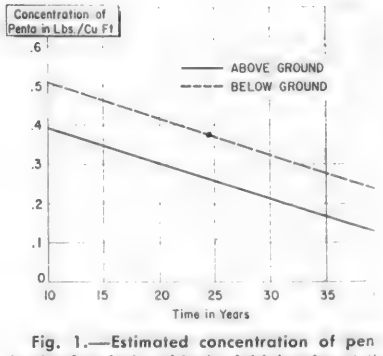

Fig. 1.—Estimated concentration of pen in the first inch, with the initial point at th first fixed analysis. (Data from the Wisco sin Power & Light Co.)

pole life by a similar method and then enter future analytical data to fill in the rest of the life-expectancy curve.

In 1954, Snoke (7) published test data in the Forest Products Journal that indicated superior preservative value for creosote fortified with 2 percent pentachlorophenol. While the preservative effect appears to be additive, this work does indicate an approach to obtaining more preservation in the wood for a given injection of total oil and thus greater protection. Here, again, test data served as the basis for wood preservative specifications when one large company adopted creosote fortified with 2 percent pentachlorophenol by weight as the standard preservative for the treatment of their Southern yellow pine poles.

New Data for Specification Writers

When a customer desires superior preservation, this same approach can be used with the normal penta-petroleum mixtures. The following laboratory and test plot data will guide specification writers to requirements that can be used to fit their needs for superior performance.

A series of soil-block tests, carried out in accordance with ASTM Standard D1413–56T were initiated to compare the threshold values of varying concentrations of pentachlorophenol in petroleum oil and other oil-type preservatives. Pentachlorophenol, an oil carrier, and a medium-residue creosote, all of which met AWPA Specifications, were used in the tests.

The data from these tests, presented in Table 2, show the threshold values of 2 percent pentachlorophenol in creosote and 7 percent pentachlorophenol solutions to be approximately the same on both weathered and unweathered blocks. The threshold values determined by a soil-block test, may be useful in writing specifications if the data are used comparatively. Because of the treatment methods, sample size and rigorous exposure conditions of the soil-block test, only an indication of the amount of preservative needed for these severe conditions is determined. Therefore, it seems the threshold data from the soil-block test can best be used for laboratory comparisons. Thus, a known and established preservative should be used as a reference point in a soil-block test to allow better use of these data.

The threshold data presented in Table 2 may be somewhat different than the results reported by others using the same test. These differences in reported threshold may result from test-block variation resulting from different geographical origin, density, oil solvents, technique in inoculation, exposure, and other minor differences not precisely covered by the ASTM procedure. The entire data show good correlation within the combination of preservative groups.

Table 2.—THRESHOLD VALUES FROM SOIL BLOCK TESTS ON FOUR PRESERVATIVE SOLUTIONS[1]

	Lenzites trabea		Lentinus lepideus	
	Unweathered	Weathered	Unweathered	Weathered
5% Penta[2]	1.1-1.8	2.1-2.6		
7% Penta[2]	.8-1.2	1.3	< .6	< .6
Creosote	<3.9	<3.9	<3.9	<3.9
Creosote + 2% Penta	1.0-1.1	1.2-1.9	< .5	.5

[1]Tests conducted at laboratories of The Dow Chemical Company.
[2]Oil carrier meeting "heavy solvent" section of AWPA Specification P-9.

Paralleling the soil-block test, a stake test was initiated in which ¾-inch by ¾-inch by 18-inch Southern yellow pine stakes were subjected to variables similar to those in the soil-block test. The data are reported in Table 3. This test has not been set up long enough for conclusive comparisons, particularly on the higher retention range. When results are coupled with the foregoing soil-block test, however, one would expect the trends which are showing up. At the latest inspection the serviceability rating of the lower retentions, as expected, are more conclusive because of the accelerated rate of attack at a lower level of protection. The serviceability of 7 percent pentachlorophenol is quite similar to that of 98 percent creosote with 2 percent pentachlorophenol at the 3 lb/cu. ft. level. This seems to bear out the soil-block test data, which indicates almost equal effectiveness. Thus, test data can again come to the aid of the specification writer, who can base his requirements on the known effectiveness of both creosote and pentachlorophenol as they have been widely used for many years.

Table 3.—SERVICEABILITY OF TREATED SOUTHERN YELLOW PINE STAKES AFTER 5 YEARS EXPOSURE[1]

Treatment	Retention lbs/cu. ft.	% Serviceability Lake Jackson, Texas	Gainesville, Florida
5% Penta[2]	8.0	77	84
6% Penta	7.0	83	85
7% Penta	3.0	67	53
	6.0	82	82
8% Penta	5.0	81	73
50% Creosote 2½% Penta 47½% oil[2]	8.1	88	89
Creosote	8.1	88	84
99% Creosote 1% Penta	7.2	90	82
98% Creosote 2% Penta	3.0	53	35
	6.1	79	79
97% Creosote 3% Penta	5.0	79	74
Oil control[2]	5.1	46	16
	8.2	74	61
Untreated control		0	0

[1]The ¾ by ¾ by 18-inch stakes were inspected Dec. 1959, and the tests were conducted at laboratories and test plots of The Dow Chemical Company.
[2]The oil carrier used was one meeting AWPA Specification P-9, Heavy Solvent and in wide use commercially for treating poles.

CO-AUTHOR Henry Huber examines test stake on Dow's experimental plot at Gainsville, Fla.

Summary

Specification writers can and do utilize the latest in results from the laboratory, test plot, and the field in writing their specifications. There are many other examples where research and development data in wood preservation can be extended into commercial practice to provide large customer benefits. Work will continue, and we are certain that new data will provide even further advances in attaining a superior treated product.

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AN EVALUATION OF 21

Rubber-Base Adhesives for Wood[1]

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Use of rubber-base adhesives might result in simplified press equipment, but there is little information about their use on wood. To fill this gap, the authors tested three types of these adhesives to determine handling characteristics, strength properties, moisture resistance, and dead-load strength.

ADHESIVES THAT INCORPORATE rubber as the principal ingredient have been in use for a number of years. These have generally been solutions of natural or synthetic rubber in organic solvents. Such adhesives, however, have been used primarily to bond materials other than wood. Recently certain neoprene-base contact cements have been used for bonding plastic laminates to wood or wood-base materials. These adhesives are of particular interest to the wood industry because they apparently develop strength rapidly at normal room temperatures. In many present operations these adhesives are used with essentially only contact pressure. Since such adhesives might simplify press equipment for wood gluing, it was of considerable interest to investigate a number of these rubber-base adhesives in conventional glued-wood joints. There was little apparent standardization of these contact adhesives and little or no information was availabe on their use in wood gluing, so a rather large number of different adhesives was included in the preliminary evaluation. A smaller number of apparently representative adhesives was then selected for more extensive additional research on the use properties and characteristics of these adhesives for wood gluing.

Preliminary Work

The 21 rubber-base adhesives used were received from 5 different manufacturers. The general properties of these adhesives as reported by the adhesive manufacturer are given in Table 1. With many of the samples, only general directions were supplied for gluing wood to wood. Most of these adhesives had been developed for other bonding applications and apparently little or nothing was known about the best methods for bonding wood. For this reason, some of the gluing conditions that were somewhat arbitrarily selected and used in the preliminary tests may not have been optimum for some of the adhesives. It was considered, however, that the relative potential of each adhesive could be reasonably judged from the preliminary test results.

In addition to the 21 rubber adhesives, 5 conventional wood glues were tested. These was listed in Table 2 as Nos. 22 thru No. 26.

Preparation of Preliminary Specimens

Three 8- by 8-inch panels were made with each of the adhesives by gluing together two pieces of yellow birch veneer, 1/16 by 8 by 8 inches, with the grain of the two plies parallel (Fig. 1).

The following gluing conditions were common to all rubber adhesives: Moisture content of veneer—6 percent; Pressure—200 pounds per square inch; Temperature—75° F.; Pressure period—5 minutes for all adhesives except No. 16, for which it was 30 minutes.

The conditions used for the conventional woodworking glues (Nos. 22 through 26) were: Moisture content of veneer—6 percent; Pressure—150 pounds per square inch; Temperature—75° F., except 310° F. for glue No. 26; Pressure periods—8 minutes for glue No. 26, 10 minutes for glue No. 23, 24 hours for glues Nos. 22, 24, and 25.

The solution-type rubber adhesives were generally applied with a roller consisting essentially of a household door spring slipped over a steel rod (Fig. 2). The unit was approximately 15 inches long and 3/8 inch in outside diameter. The adhesive was poured onto the veneer sheet and distributed by moving the spring-roller over the surface. This had the same effect as using a notched trowel with shallow and uniformly spaced notches. The mastics were applied with a notched trowel having 1/8-inch-deep triangular slots with the tips 1/8 inch apart. A brush was used to apply the emulsions and the conventional wood-working adhesives.

The number of coats of glue applied and the assembly times used are included in Table 2. The amount of adhesive spread on the veneers was determined on representative pieces by weighing the veneers before and after they were spread. Such weights were used in deciding whether one or two coats of adhesive were necessary to provide sufficient adhesive solids in the joints.

Six shear test specimens were cut from each panel made as shown in Figure 1. These were essentially simple lap specimens (Fig. 3A) with built-in shims that facilitated uniform alinement and loading in the jaws of a conventional plywood shear test machine.

Two specimens from each panel were tested dry, 1 week after gluing.

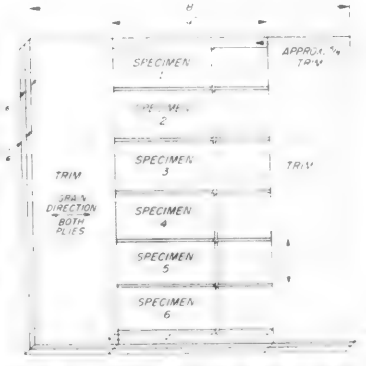


Fig. 1.—Cutting diagram of test specimens. Two rows of similar specimens were obtained from each 8– by 9-inch panel.

The Authors: Dr. Richard F. Blomquist is in charge of the Section of Glues and Gluing in the Laboratory's Division of Timber Processing. He is also Chairman of FPRS Division of Glues and Gluing Processes. Warren Z. Olson, chemist in the Glues and Gluing Section, is a graduate of the University of Wisconsin and a frequent contributor to the Journal.

[1] Presented at Session IX, Glues and Gluing, FPRS 14th Annual Meeting, June 7, 1960 in Montreal, Canada; revised for publication September 5, 1960.

[2] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

ig. 2.—Rubber-base adhesives were spread on the veneer with a spring roller.

n a conventional plywood shear test nachine. One inch at each end of the pecimen was clamped in the jaws of he test grips. Loading was at 600 to 1,000 pounds per minute. This general test procedure was followed throughout the work covered by this report.

Two other specimens from each panel were tested dry 7 weeks after gluing, and two were tested wet 5 weeks after gluing after soaking for 48 hours in water at room temperature. Percentages of wood failure were also estimated for each broken specimen.

Preliminary Results

The results of the preliminary tests are included in Table 2 and summarized in Figure 4.

Joint Strength: Solution-type adhesives 2, 9, 10, 11, and 12 had average shear strength values of less than 100 pounds per square inch after 1 week. The strongest was No. 4 which was almost 11 times as strong as the weakest, No. 9. After 7 weeks all specimens showed increased joint strength, but those that were low after 1 week generally remained among the lowest. Adhesives 4 and 8 increased, to over 600 pounds with aging. In comparison with adhesives 25, 26, 27, and 28, there was little or no wood failure with the solution-type. This indicates the comparatively low cohesive strength of the solution-type rubber adhesives, which are completely polymerized as received. They developed strength by loss of solvent, which takes place slowly. Even when nearly dry, the adhesive films often have rather low cohesive strengths compared to conventional wood glues. Wet strength of the specimens after 5 weeks of aging was generally lower than the dry strength at 1 week, except for adhesives 9 and 12.

Of the emulsion-type adhesives, adhesive 18 was low in strength after 1 week. Adhesive 17 was essentially as strong as the best solvent-type adhesive, and it increased in dry shear strength to 830 pounds in 7 weeks. Adhesive 16 also showed an increase. Again there was no failure in the wood in these specimens. As with the solvent-type adhesives, wet strength after 5 weeks was low, and adhesive 18, a very thin emulsion, failed completely.

None of the mastics had much dry strength 1 week after gluing, but they increased after 7 weeks. No wood failure was noted, and wet strength was low.

The nonrubber glues (Nos. 22 to 26) were generally higher in dry strength than the rubber adhesives and also showed considerable wood failure in the dry condition. In the wet tests, the polyvinyl emulsion glues, Nos. 22 and 23, had less strength than most of the rubber adhesives.

Types of Failure in Broken Specimens: It appeared that the adhesives failed principally in cohesion within the adhesive film, as shown in Figures 5 and 6. No particular type of failure was associated exclusively with any of the adhesives tested. Solution adhesives 2, 8, and 13 showed small areas of adhesion failure, while Nos. 1, 3, 4, and 7 showed small areas that were difficult to classify, but might have been adhesion failure. There appeared to be little or no evidence of adhesion failure between the layers of adhesive applied to the two joining surfaces. Emulsion adhesives 16 and 17 failed in adhesion to wood, while No. 18 failed in film cohesion. All three of

Table 1.—DESCRIPTION[1] OF THE 21 RUBBER-BASE AND 5 NONRUBBER ADHESIVES EVALUATED

Adhesive No.	Base composition	Solvent	Solids content Percent	Consistency
1				
2	Reclaimed rubber	Petroleum naphtha	48 ±3	Medium syrup
3	Oil-resistant elastomer	Acetone	37 ±3	Do
4	Do	Naphtha, toluene, methyl ethyl ketone	37 ±2	Thin syrup
5	Do	Naphtha, toluene and ketones	25 ±2	Do
6				
7	Oil-resistant elastomer and resins		25	1,500 centipoises
8	Neoprene-phenolic		25 ±1	750 centipoises
9	Synthetic rubber and resin	Methyl ethyl ketone and toluene	30	600 centipoises at 72° F.
10	Neoprene	Toluene	30	460 centipoises
11				
12	Buna N rubber and phenolic resin	Methyl ethyl ketone	24.1 ±2	Medium
13	Synthetic rubber and synthetic resins	do	26	500 to 600 centipoises
14	Do		24 to 27	625 centipoises
15		Water		
16			20	1,500 centipoises
17	Modified elastomer	Water	50	
18		do		
19	Synthetic rubber	Naphtha	65 ±3	Mastic
20	Synthetic rubber and synthetic resin	Tolutene or xylene	48	Do
21	Reclaimed rubber	Benzosol	65 to 70	Mastic
22	Polyvinyl acetate	Water	55	
23	Polyvinyl copolymer	do	58	700 Stormer grams LP-100 revolutions per minute
24	Casein	do	33	[2]
25	Phenol-resorcinol resin	Water alcohol	65	[2]
26	Phenol resin	do	50	[2]

[1]Taken from adhesive manufacturer's literature where available. Blanks indicate no information was given in literature. No analyses were made at the Forest Products Laboratory.
[2]Consistency may vary depending on how soon measured after the glue was mixed.

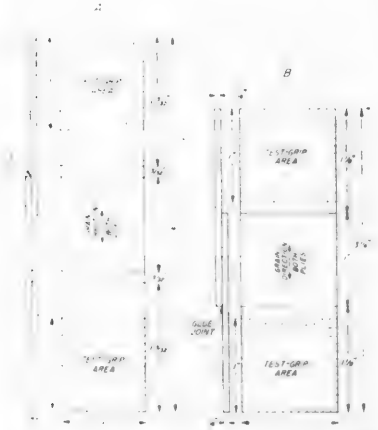


Fig. 3.—Lap-joint specimens: (A) 4-inch ecimen cut from panel as in figure 1 (pre-ared by bonding two veneers, making saw rfs to define test areas, and then cutting to individual specimens); (B) 3¼-inch ecimen made individually by bonding two ips of veneer.

Fig. 4.—Range of average dry-test values for 25 different rubber-base and other adhesives included in preliminary study.

the mastics (Nos. 19, 20, and 21) failed in cohesion.

Many of the adhesives showed a tendency to rebond after the bond areas were separated in test and then placed together in storage for several weeks. Adhesives 2, 3, 6, 9, and 21 rebonded strongly; adhesives 14, 17, and 20 rebonded weakly; and adhesives 11, 12, 13, 15, 16, 18, and 19 were intermediate between the first two groups in the apparent amount of force required to separate the rebonded joints by hand.

Adhesives 2 and 18 were quite tacky in the broken specimen after several months; adhesives 16 and 21 were tacky; and adhesives 3, 6, 17, 19, and 20 were slightly tacky.

Failure in matched specimens tested wet were not appreciably different from those in specimens tested dry.

To learn more about the nature of the failures on a lap-joint specimen made with one typical solution-type rubber-adhesive (No. 4), one portion of the adhesive was dyed a dark red, and the other portion was left a natural yellow color. Two-ply panels, 8 by 8 inches, were made up as in earlier work (Fig. 1) by hand-roller spreading one veneer surface with the yellow portion, and the other veneer with the red portion. One panel was then made after 5, 8, 10, or 12 minutes open assembly at room conditions, and each was pressed for 5 minutes at room temperature under 150 pounds per sqaure inch. Panels were aged at 80° F. and 30 percent relative humidity for 14 days before the specimens were cut and tested. Specimens tested for each assembly period are shown in Figure 7. Average joint strength values were 482, 422, and 412 pounds per square inch for 5, 8, and 10 minutes, respectively, and 340 pounds per square inch for the 12-minute period. Failure in the first three groups was largely cohesive in one or the other original film, generally showing some yellow and some red areas. However, the 12-minute specimens each showed primarily yellow failure on one broken piece and red on the opposite piece. This indicates a lack of adhesion of one partially dried film to the other because of excessive air drying, and it may be a reason for the lower joint strength.

Table 2.—RESULTS OF PRELIMINARY JOINT TESTS[1] OF RUBBER ADHESIVES, AND RESULTS OF SIMILAR TESTS FOR SEVERAL NONRUBBER GLUES

Adhesive No.	Number of coats of adhesive applied	Assembly time[2]		Results of shear tests					
				dry after 1 week[3]		Dry after 7 weeks[4]		Wet after 5 weeks[5]	
		After first coat Min.	After second coat Min.	Shear strength P.s.i.	Wood failure Percent	Shear strength P.s.i.	Wood failure Percent	Shear strength P.s.i.	Wood failure Percent
RUBBER ADHESIVES—SOLUTION TYPE									
1	2	5	60	282	0	277	0	219	0
2	[6]1	5	.	53	0	101	0	12	0
3	2	10	20	147	0	328	0	107	0
4	1	8	.	457	0	624	1	312	0
5	1	5	.	201	0	228	0	87	0
6	1	5	.	217	0	225	0	113	0
7	1	5	.	193	0	296	0	128	0
8	2	5	60	281	0	682	10	165	0
9	2	20	20	42	0	168	0	160	0
10	1	15	..	58	0	93	0	57	0
11	1	10	.	72	0	153	0	38	0
12	2	10	10	88	0	252	3	119	2
13	1	15	.	165	0	228	0	142	0
14	1	10	.	300	0	427	7	172	0
15	1	20	.	249	0	337	0	175	0
RUBBER ADHESIVES—EMULSION TYPE									
16	1	15	..	278	0	345	0	97	0
17	1	30	.	440	0	830	0	155	0
18	2	5	5	81	0	-	..	0	0
RUBBER ADHESIVE—MASTIC TYPE									
19	[6]1	10	.	32	0	65	0	49	0
20	[6]1	15	.	62	0	385	0	92	0
21	[6]1	30	.	101	0	143	0	85	0
NONRUBBER GLUES									
22	[6]1	2 to 4	.	968	100	879	93	0	0
23	[6]1	5	.	818	68	912	95	9	0
24	[6]1	3 to 5	..	859	33	696	36	175	0
25	[6]1	9 to 11	.	681	69	644	98	558	97
26	—1	120	..	669	92	527	98	442	89

[1]Each average test value is for a total of 6 specimens from 3 panels.
[2]Assembly was open for all adhesives through No. 21, and closed for the nonrubber adhesives.
[3]Tested at about 6 percent moisture content 1 week after gluing.
[4]Tested at about 6 percent moisture content 7 weeks after gluing.
[5]Tested after soaking for 48 hours in water at room temperature.
[6]Adhesive applied to only one surface, all others applied to both surfaces.

Rate of Joint Strength Development

This portion of the work was divided into two parts. In the first part, the rate of joint strength development during the first 24 hours was investigated in order to get a comparison of this property between rubber adhesives and several conventional adhesives. In the second part, the change in joint strength over 32 weeks was determined for five of the rubber adhesives.

Strength Development During First 24 Hours

To determine the development of joint strength in the first 24 hours tests were made with emulsion adhesive No. 17, solution adhesives Nos. 4 and 14, a polyvinyl-resin emulsion, a urea resin, a phenol-resorcinol resin, and a casein glue.

To faciliate rapid testing specimens, as shown in Figure 3B, were made with each adhesive for each of a number of aging periods. The veneers were at 6 percent moisture content, the pressure was 200 pounds per square inch, and the temper-

Fig. 5.—Typical failures in lap-joint specimens: R is resorcinol glue No. 25; P is polyvinyl glue No. 22; Nos. 20 and 21 are mastic types of rubber adhesives; Nos. 16 and 17 are emulsion types.

Fig. 6.—Typical failures in lap-joint test specimens. Solution-type rubber-base adhesives Nos. 3, 8, 6, 1, 4, and 14.

Table 3.—RESULTS[1] OF DRY SHEAR TESTS OF YELLOW BIRCH LAP JOINTS[2] MADE WITH THREE RUBBER ADHESIVES AND FIVE CONVENTIONAL GLUES AND CURED UP TO 24 HOURS

Cure period	Rubber adhesives			Conventional glues				
	No. 4 (solution)	No. 14 (solution)	No. 17 (emulsion)	Animal	Casein	Polyvinyl	Urea	Resorcinol
0 min.	48–0		135–0			324–0		
5 min.					53–0	417–0		
20 min.	43–0	75–0	98–0			512–0		
40 min.	62–0	96–0	265–0	21–0	145–0		0–0	0–0
45 min.						738–9		
1 hr.	40–0	92–0	278–0	193–0	322–0	815–6	100–0	0–0
4 hr.	143–0	166–0	296–0	678–8	470–0	1015–57	417–0	298–0
7 hr.	136–0	243–0	365–0	720–12	556–0	1064–82	468–0	420–0
24 hrs.	270–0	356–0	373–0	762–13	529–0	936–17	707–26	690–4

[1]Value before dash is average shear strength in pounds per square inch; value after dash is average estimated wood failure in percent. Each value is the average for 5 individual lap shear specimens.
[2]Two strips, 1/8 by 1 by 2 1/2 inches, were overlapped for 1 inch to form a 1-square-inch test area.

ture 75° F. The following spreading and assembly conditions were used (glue applied with brush):

Rubber adhesive 4—One coat applied to each surface, 5 minutes open assembly.

Rubber adhesive 14—Two coats applied to each surface, 5 minutes between coats, 10 minutes open assembly after second coat.

Rubber adhesive 17—One coat applied to each surface, 2 minutes open assembly.

Animal glue—One coat applied to one surface, 5 minutes closed assembly.

Polyvinyl, casein, and urea glues—One coat applied to one surface, immediate closed assembly.

Resorcinol glue—One coat applied to one surface, 15 minutes closed assembly.

All specimens were under pressure for the selected period up to and including the 7-hour period. They were tested immediately upon removal from the press. Those tested at 24 hours were removed from the press at 8 hours.

For minimum eccentricity, the glue line was centered in the grips with one end of the specimen offset to the right of center and the other end to the left of center.

The results of the shear tests are included in table 3. With the shear strength data from this table, smooth curves were developed as shown in Figure 8. The rubber adhesives developed some positive strength immediately on contact as evidenced by their definite resistance to movement after only momentary contact. None of the conventional glues showed this characteristic.

Strength Development Over 32 Weeks

As a result of these tests, it was considered desirable to prepare joints with the more promising rubber adhesives and age them for several weeks at room temperature to determine the approximate time required to reach full strength.

Seven 8- by 9-inch, 2-ply panels as shown in Figure 1, were made for each of five adhesives. The glues tested were Nos. 4, 12, 14 and Nos. 16, 17. Conditions were the same as in the consideration of joint strength development during the first 24 hours, except that adhesives were applied with the spring-roll spreader. After 5 minutes under pressure, the panels were removed and stored at 80° F. and 30 percent relative humidity. Specimens were cut from the panels just prior to the 1-week tests. For the longer aging periods, the individual specimens were stored at 80° F. and 30 percent relative humidity until tested.

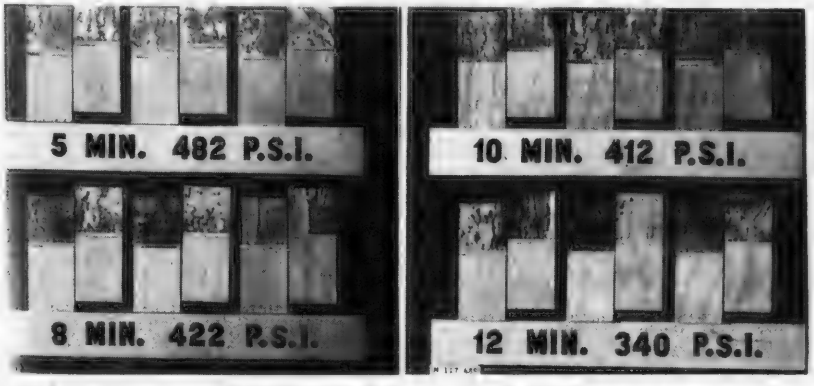
Twelve shear specimens, each with a 1-square-inch test area, were cut from each panel. The specimens for each adhesive were randomly divided into 8 groups of 10 specimens each. These were stored at 80° F. and 30 percent relative humidity and one group was tested dry at each of the following periods after gluing: 1, 2, 4, 8, 16, and 32 weeks. Another group was tested wet after soaking for 48 hours in water at room temperature one week after gluing, and the eighth group was tested wet after this soaking procedure 32 weeks after gluing.

The results of the shear tests are included in Table 4 and shown in Figure 9. Adhesives Nos. 12, 14, and 17 reached 85 percent or more of their highest dry strength in 2 to 4 weeks. No. 4 reached this level in 4 to 8 weeks, and No. 16 in the first week. These final levels of strength, however, varied from approximately 350 to 850 pounds per square inch. All adhesives reached 70 percent or more of their highest strength within 4 weeks. Adhesives 4 and 12 reached their highest dry strength values only after 32 weeks, indicating that they still might not have yet reached their maximum strength. Most significant increases were made with all adhesives, however, in 4 weeks or less.

Adhesive 16, an emulsion type, had approximately the same wet strength at 32 weeks as it did at 1 week, and this was the lowest wet strength noted in this series. The other four adhesives all gained in wet strength during this period with adhesive 4 gaining about 75 percent, the highest wet strength in this series.

The rubber adhesives, despite development of some strength immediately on contact, develop full strength more slowly at normal room temperatures than do the conventional adhesives, which are considered to develop essentially full strength in less than a week, most of them in a few days or less.

These results indicate that in general the solution- and emulsion-type adhesives as groups were essentially equivalent in final levels of strength.



g. 7.—Failures revealed by the use of dye in adhesive 4. Assembly periods used and average joint strength are indicated.

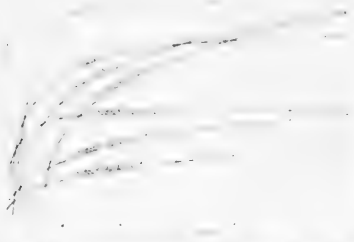


Fig. 8.—Development of strength, up to 24 hours, for various adhesives in yellow birch lap joints.

Table 4.—RESULTS[1] OF SHEAR TESTS OF YELLOW BIRCH SPECIMENS[2] AFTER AGING PERIODS OF 1 TO 32 WEEKS

Adhesive No. and type	Test condition[3]	Weeks of aging at 80° F., 30 percent relative humidity					
		1	2	4	8	16	32
4 (solution)	Dry	470–0	593–15	593–4	832–10	806–49	853–31
	Wet	238–0					415–0
12 (solution)	Dry	224–0	322–8	564–12	542–18	586–0	642–18
	Wet	206–10					286–0
14 (solution)	Dry	420–0	331–0	454–0	348–0	532–90	489–0
	Wet	153–0					203–0
16 (emulsion)	Dry	386–0	376–0	392–0	390–0	373–0	344–0
	Wet	90–0					95–0
17 (emulsion)	Dry	494–0	610–0	713–24	752–4	819–39	780–36
	Wet	127–0					192–0

[1]Value before dash is average shear strength in pounds per square inch; value after dash is average estimated wood failure in percent. Each value is average for 10 specimens randomly selected from 7 panels.
[2]Two-ply lap-type specimens, 1 inch wide, 4 inches long, and 1 square inch test area.
[3]Tested dry at about 6 percent moisture content; tested wet after soaking for 48 hours in water at room temperature.

The lowest and highest dry test values after 32 weeks were obtained with emulsion-type adhesives.

Variations in Assembly Period and Temperature

For some types of conventional wood adhesives in certain applications, the assembly conditions are critical. Hot animal glues, for example, can produce either strong joints under proper conditions or weak joints if conditions are otherwise. Joints may be weak when a short assembly time is used because normal gluing pressure forces the thin glue out of the joint or into the wood, or because the use of a long assembly time allows the glue to become too thick to transfer to the other surfaces.

Other glues may be less critical than animal glue in regard to assembly time, but each has a limited range where it will produce highest joint quality. The general recommendation of manufacturers of rubber adhesives is for a long open assembly period at room temperatures or the use of heat to drive the solvent from the adhesive film after application. Such removal of solvent after application is needed to allow the rubber film to develop higher cohesive strength when it is momentarily pressed together. Presumably excessive drying could result in lack of wetting or contact of the films on the two mating surfaces. Because most experience with rubber adhesives has been with metals, plastics, or other nonabsorbent materials, it was desirable that some investigation be made of the effect of certain assembly conditions in gluing wood with these adhesives.

Assembly Periods at Room Temperature

Procedures: A solution-type adhesive (No. 4) and an emulsion-type adhesive (No. 17) were used in making the specimens. One panel was made with each adhesive at each assembly time. A panel consisted of two 8- by 9-inch sheets of 1/16-inch yellow birch veneer glued together with grain parallel, essentially as in Figure 1. The gluing conditions were:

Moisture content of veneer: 6 percent.
Adhesive spread: One coat applied to each surface with the spring roller (every effort was made to insure uniform adhesive spreads on the different panels of each adhesive).
Assembly times (open): 1, 5, 10, 15, and 20 minutes.
Pressure: 200 pounds per square inch.
Temperature: 75° F.
Pressure period: 1 hour for 1-minute assembly time, 10 minutes for 5-minute assembly time, 5 minutes for other assembly times.

Twelve specimens, 1 inch wide, 4 inches long, with an overlap test area of 1 square inch, were cut from each panel. Six specimens from each panel were tested dry after 1 week and the other six were tested dry after 7 weeks. For the period between preparation and test, the specimens were stored at 80° F. and 30 percent relative humidity.

Results: The results of shear tests of the specimens are included in Table 5. These results appear logical when the mechanism of bond formation is considered. The adhesive must lose a major proportion of its solvent to develop high strength, but must retain enough solvent at the time of application of pressure to allow the adhesive to flow and thus make intimate contact with the wood surface and with the adhesive on the opposite surface. The solution-type adhesive probably loses considerable solvent in the first few minutes of open assembly, but retains enough to bond to the adhesive film on the other surface and fill the irregularities of the wood surface.

Table 5.—EFFECT OF ASSEMBLY TIME AT 75° F. ON THE STRENGTH OF LAP JOINTS MADE WITH RUBBER ADHESIVES

Adhesive		Assembly time (open) Minutes	Shear test results[1]	
No.	Type		After 1 week	After 7 weeks
4	Solution	1	69–0	140–0
		5	424–0	617–0
		10	471–0	638–1
		15	447–0	619–0
		20	392–0	670–29
17	Emulsion	1	419–0	352–0
		5	450–0	422–0
		10	357–0	318–0
		15	332–0	298–0
		20	308–0	281–0

[1]Value before dash is average shear strength in pounds per square inch; value after dash is average estimated wood failure in percent. Each value is the average for 6 specimens from one panel.

The remaining solvent is then probably lost more slowly and keeps the adhesive at the proper viscosity through at least a 20-minute assembly period. The emulsion-type adhesive probably loses most of its water to the wood and has a tendency to dry at the surface in the longer assembly periods and reduce the ability to bond to the other glued surface. The best condition for bonding with such an emulsion-type rubber adhesive apparently is between 1 and 5 minutes.

Temperature Variations in Assembly and Pressing

To determine the possible advantages of heat in removing solvent during the assembly period, several variations were explored with one of the better solution-type adhesives (No 14). One variation was drying and pressing at 215° F. to simulate temperature conditions that might prevail in a nip-roll pressure process when the adhesive films had just been dried in an infrared heating system.

Procedures: Two 2-ply, 8- by 9-inch panels, as in Figure 1, were made with 1/16-inch yellow birch under each of four conditions with the solution-type adhesive (No. 14):

Condition 1: Ten minutes' open assembly time allowed between applications of adhesive, then 5 minutes' open assembly time al

Fig. 9.—Development of strength, up i 32 weeks, for 5 rubber-base adhesives i yellow birch lap joints.

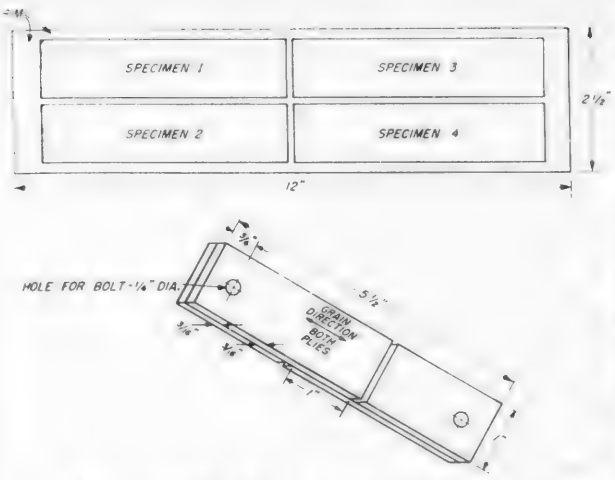


Fig. 10.—Cutting diagram for dead-load specimens from joint, and detail of individual specimen.

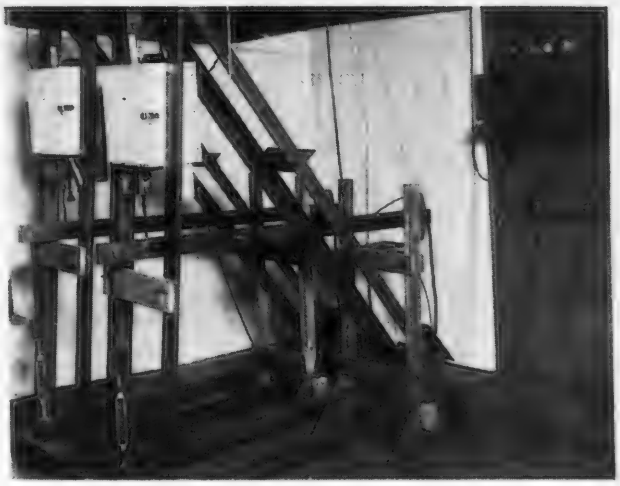


Fig. 11.—Apparatus for dead-load tests; cabinets were used for tests at 110° F.

lowed after second coat, all at room temperature. Pressed at room temperature for 5 minutes.

Condition 2: Same assembly conditions as in condition 1, but pressed at 215° F. for 5 minutes.

Condition 3: Ten minutes' open assembly time allowed at room temperature between applications of adhesive, then 5 minutes' open assembly time in an oven at 215° F. Pressed at room temperature for 5 minutes.

Condition 4: Same as condition 3, but pressed at 215° F. for 5 minutes.

The moisture content of the veneer was 6 percent, the adhesive was applied with spring roller, and the pressure applied was 200 pounds per square inch. Twelve lap-type shear specimens were cut from each panel after panels had been stored for 1 week at 80° F. and 30 percent relative humidity. Six of these were tested dry after 1 week, and six were tested wet after 1 week, after being soaked for 48 hours in water at room temperature. The results of shear tests of the specimens are included in Table 6.

Ability to Sustain Dead Load

In many use conditions a glued wood joint must have the ability to sustain a rather high load for an indefinite period. Under exposure to high temperatures or to high humidity, the glue must not soften or become so plastic that it will fail under the load it carries under less severe conditions. For some important uses in good gluing, thermoplastic glues, such as polyvinyl resins, have been restricted because of the lack of resistance to dead loading at high temperatures, or under conditions of high humidity. Rubber adhesives are also generally considered elastic, and it was desirable, therefore, that data on this property be obtained for comparison with data obtained on other types of more conventional wood glues.

Preparation of Specimens

Two solution-type adhesives (Nos. 12 and 14) and two of the emulsion type (Nos. 16 and 17) were used. Joints were prepared by gluing together two 3/16- by 2-½- by 12-inch pieces of hard maple lumber that had been jointed just before they were bonded. Joints and test specimens cut from these joints are shown in Figure 11. The moisture content of the wood was 6 percent, the pressure 200 pounds per square inch, the temperature 75° F., and the pressure period 30 minutes. The adhesives were applied with the spring roller, and the following spreading and assembly conditions were used:

Solution-type adhesives 12 and 14: Two coats of adhesive were applied to each surface. Ten minutes' open assembly was allowed between first and second coats and 5 minutes' open assembly after the second coat, all at room temperature.

Emulsion-type adhesives 16 and 17: One coat of adhesive was applied to each surface. Assembly was immediate at room temperature.

Four test specimens were cut from each joint. Each specimen was 1 inch wide and 5-½ inches long, with saw kerfs made through opposite faces to the glue line to form a 1-square-inch test area at the center. Specimens were allowed to condition at 80° F. and 30 percent relative humidity for at least 4 weeks before testing.

Dead-Load Tests

One specimen from each joint was tested in tensile shear in a plywood testing machine with load applied at 600 to 1,000 pounds per minute to obtain a level that would indicate a range of dead loads which could be applied. The average joint strength when tested in this manner was 875 pounds per square inch for adhesive No. 12, 943 pounds per square inch for adhesive 14, 258 pounds per square inch for adhesive 16, and 728 pounds per square inch for adhesive 17. The dead-load tests were made in the apparatus shown in Figure 12. Through a lever-arm system the load was applied to the specimen, which was gripped in a vertical position (Fig. 13). Principal stress on the glue joint was applied in tensile shear. An automatic electrical timing device was used to record the time to failure. When a specimen sustained a selected load for 200 hours, it was removed

Table 6.—EFFECT OF HEAT IN ASSEMBLY AND PRESSING ON THE STRENGTH OF YELLOW BIRCH LAP JOINTS MADE WITH SOLUTION-TYPE RUBBER ADHESIVES

Assembly conditions	Press[1] temperature	Shear test results[2] Dry after 1 week[3]	Wet after 1 week[4]
10 minutes open after first coat, 5 minutes open after second coat; both at 75° F.	75° F.	356- 0	156- 0
Do	215° F.	578- 26	198- 0
10 minutes at 75° F. after first coat, 5 minutes open at 215° F. after second coat	75° F.	307- 0	96- 0
Do	215° F.	340- 0	98- 0

[1]Time under pressure: 5 minutes.

[2]Value before dash is average shear strength in pounds per square inch; value after the dash is average estimated wood failure in percent. Each value is for a total of 12 specimens from 2 panels.

[3]Tested at about 6 percent moisture content after 1 week at 80° F. and 30 percent relative humidity.

[4]Tested after soaking for 48 hours in water at room temperature, following 1 week at 80° F. and 30 percent relative humidity.

Fig. 12.—Specimen positioned for dead-load test. Note heating elements and thermostatic control for tests at elevated temperatures.

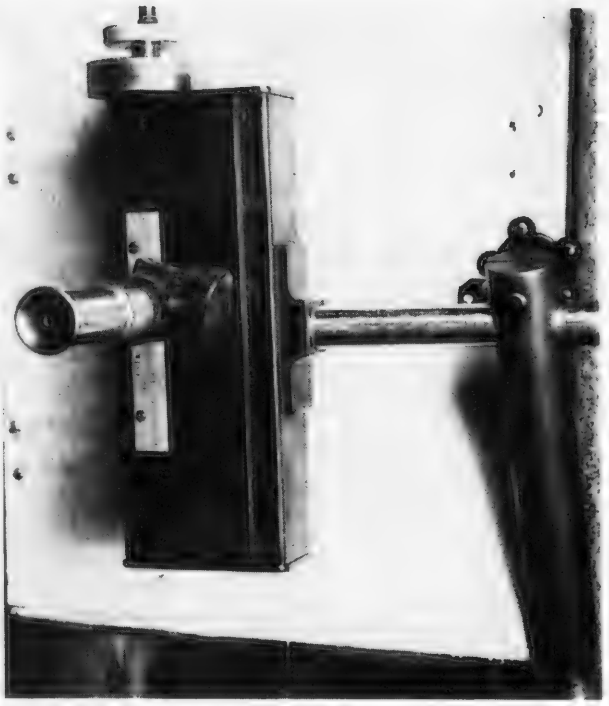


Fig. 13.—Traveling microscope in place for measurement of creep in a dead-load specimen.

and replaced by another specimen to which a higher load was applied. Tests were made at 75° F., at 110° F. without humidity control, and at 80° F. with the relative humidity at 90 percent.

Several measurements of the creep in the glue line while under load were made, using the traveling microscope as shown in Figure 14. A fine groove was cut with a razor blade across the edge of the specimen at the center of the test area as an index, and the displacement of this mark was measured.

Discussion of Dead-Load Results: The results of the dead-load tests are shown in Figures 15 through 17. The curves drawn indicate that the following maximum loads might be sustained for 200 hours:

Test Condition	No. 12 P.s.i.	No. 14 P.s.i.	No. 16 P.s.i.	No. 17 P.s.i.
75° F.	100	520	30	435
110° F.	85	220	10	100
80° F.—90% R.H.	170	250	15	230

The above figures indicate the wide variation possible in the ability of adhesives of this type to withstand dead loads. Apparently the adhesive bonds are weakened somewhat by a temperature of 110° F., less by a high humidity (90 percent relative humidity at 80° F.,), and least at normal room conditions (75° F.).

Comparable values obtained at the Forest Products Laboratory with polyvinyl emulsion glues (Nos. 1, 2, and 3) and hot animal glue (No. 4) under the same test conditions were:

Test Condition	No. 1 P.s.i.	No. 2 P.s.i.	No. 3 P.s.i.	No. 4 P.s.i.
75° F.	765	765	555	674
110° F.	160	160	10	460
80° F.—90% R.H.	80	40	5	124

Values for these groups indicate that the rubber adhesives are generally capable of sustaining higher loads than polyvinyl and animal glues at 80° F. and 90 percent relative humidity. At 75° F. the polyvinyl and animal glues can sustain higher loads. At 110° F. the rubber and polyvinyl adhesives are similar in ability to sustain loads, while the animal glue is superior to both types.

Some typical creep measurements made under load during the deadload tests, with comparable measurements of creep for a polyvinyl glue, are:

Test condition	Adhesive	Load P.s.i.	Time Hr.	Creep In.
75° F.	14	613	200	0.0035
		635	200	.0023
	12	95	200	.0012
	17	400	200	.0090
	22	715	187	.0019
110° F.	14	224	200	.0122
		298	200	.0116
	22	360	2	.0126

These values are not necessarily the maximum amount of creep. The above measurements indicate that as the temperature increases, the amount of creep increases very distinctly with both the rubber adhesive No. 14 and the polyvinyl resin No. 22. This explains why the dead loads that can be supported at 110° F. are lower than those at 75° F.

Evaluation of Permanence

Initial accelerated tests of glue joints, such as the conventional boil-cycle or soak-dry cycles for plywood specimens, form a good basis on which to judge durability of the glue under some use conditions, if the glue tested is of a type for which long-term durability data have been obtained. Various types of adhesives have been tested under both accelerated and long-term tests[3] at the U. S. Forest Products Laboratory. The use of rubber adhesives in wood joints, however, is so recent a development that little durability data for such applications are available.

It was desirable, therefore, that a long-term exposure study be started to obtain data for comparison with other types of glues. Such a series of laboratory-controlled exposures was only recently begun and will be continued for several years. As yet they have not run long enough to give any significant information. However, some indications of probable performance may be found in the results of control tests for this series, as well as in a series of weather exposures begun in 1956.

Laboratory-Controlled Exposures

Two exposure conditions are being used in this long-term evaluation in the laboratory. One condition is

[3] U.S. Forest Products Laboratory. Durability of Water-Resistant Woodworking Glues. Forest Products Lab. Rept. No. 1530, (Revised) 1956.

continuous exposure at 158° F. and 20 percent relative humidity, and the other is a repeating cycle that consists of 4 weeks at 90 percent relative humidity followed by 4 weeks at 30 percent relative humidity. Ten specimens for each adhesive, from each exposure, will be tested without reconditioning after each of these periods of exposure: 6, 12, 18, 24, 30, 36, 42, 48, 54, and 60 months.

These tests have not been under way long enough yet to provide significant data but the results of the control tests for this series have laid the basis for a comparison with results of similar tests of conventional woodworking glues.

Control Tests

Preparation of Specimens: For the laboratory exposure studies, thirteen 3-ply yellow birch plywood panels, using 1/16- by 12- by 12-inch veneers, were made with each of seven adhesives from the present study. These adhesives included three of the solution type (Nos. 4, 12, 14), two of the emulsion type (Nos. 16, 17), and one of the mastic type (No. 20).

The solution-type and the emulsion-type adhesives were applied to the veneers with a spring roller. The mastic was applied to one surface with a trowel having grooves 1/8 inch deep and 1/8 inch apart. The moisture content of the veneers was 6 percent, pressure 200 pounds per square inch, temperature 75° F., and the pressure period 10 minutes. Two coats of solution-type adhesives 12 and 14 were applied to each surface, with a 5-minute open assembly time between coats and a 10-minute open assembly time after the second coat. The other solution-type adhesive (No. 4) and the two emulsion-type adhesives (Nos. 16, 17) were applied one coat to each surface. Assembly periods were 5 minutes for adhesive 4 and 1 minute for the emulsion-type adhesives. These bonding conditions had been selected as most favorable in previous work.

One 6- by 6-inch square was cut from each of 3 panels for each adhesive. The remainder of these 3 panels, and also all of the other 10 panels for each adhesive, were cut into standard plywood shear specimens (ASTM D906–55). These specimens were divided randomly into groups for initial control tests and for exposure tests. All specimens were aged for at least 4 weeks at 80° F. and 30 percent relative humidity before any tests were made.

Method of Test: The initial test conditions for the shear specimens were as follows:

1. Tested dry at about 6 percent moisture content.
2. Tested wet after soaking for 48 hours in water at room temperature.
3. Tested dry at 160° (+5°)F. after 30 minutes at this temperature.
4. Tested wet after immersion for 4 hours in boiling water, drying for 20 hours at 145° (+5°)F., immersion again for 4 hours in boiling water, and cooling in water to room temperature.
5. Tested at about 20 percent moisture content after 1 week at 80° F. and 90 percent relative humidity.

The 6- by 6-inch specimens were subjected to 15 cycles of soaking and drying. Each cycle consisted of 4 hours of soaking in water at 75° F., followed by 20 hours of drying at 75° F. At the end of the drying period of each cycle, the edges of the panels were inspected and the length of any glue line delamination that was at least 1/8 inch deep was measured and recorded.

Results: The results of initial tests are included in Table 7. It will be noted that the dry plywood shear strengths are lower than those found for the corresponding adhesive in lap joints in other parts of this study. This difference is due principally to the types of specimen and the stresses exerted on these joints under test.

According to available data from other earlier work, polyvinyl glues, such as glue 22 in Table 1, and animal glues lose all strength in the 48-hour soak test; glues such as casein, urea, phenol, and resorcinol resins generally retain a higher wet strength than has been retained by these rubber adhesives.

In the delamination test of 6- by 6-inch specimens, Commercial Standard CS 35–56 requires that Type II plywood must withstand an average of 10 cycles of soaking and drying without a failing delamination, which is defined as one greater than 2 inches in length, and more than 1/8 inch in depth. In the present tests the performance of individual specimens was more variable than is usually noted for conventional wood glues in laboratory-prepared panels. This may be due to variability in spreading larger panels uniformly with rubber adhesives with the hand roller technique.

In previous tests it was found that animal and polyvinyl emulsion glues fail to meet this standard delamination requirement after 2 cycles of soaking and drying, while such glues as casein, urea, melamine-urea, and resorcinol resins are capable of easily meeting the standard 10-cycle requirement.

Fig. 14.—Relation between applied load at 75° F. and time to failure of hard maple lap joints made with 4 rubber-base adhesives.

Weather Exposure Series

In 1956, plywood panels, made with five solution-type rubber adhesives available at that time, were exposed to weather near Madison. None of these adhesives were used in the present studies in earlier parts of this report. Each panel consisted of three plies of 1/16-inch yellow birch veneers. They were prepared as 25- by 25-inch panels cut to 18 by 18 inches, and exposed unprotected, facing south in a vertical position. The gluing conditions are included in Table 8.

Fig. 15.—Relation between applied load at 110° F. and time to failure of hard maple lap joints made with 4 rubber-base adhesives.

Fig. 16.—Relation between applied load at 80° F. and 90 percent relative humidity and time to failure of hard maple lap joints made with 4 rubber-base adhesives.

Table 7.—RESULTS OF INITIAL CONTROL TESTS OF BIRCH PLYWOOD SPECIMENS[1] BEFORE EXPOSURE OF SHEAR SPECIMENS TO CONTROLLED TEMPERATURE AND HUMIDITY CONDITIONS

Rubber adhesive		Shear test results[2]					Delamination test results[3]		
No.	Type	Dry[4] test	Wet[5] test	Boil[6] test	160° F.[7] test	Moist[8] test	Specimen No.	Cycles[9] before failure	Met requirement[10]
4	(solution)	288–10	117–0	57–0	248–0	243–0	1	15	+
							2	4	—
							3	15	+
12	(solution)	212–0	99–0	9–0	21–0	210–0	1	0	—
							2	0	—
							3	12	+
14	(solution)	286–4	111–0	73–0	188–0	382–8	1	15	+
							2	6	—
							3	4	+
16	(emulsion)	181–0	53–0	12–0	35–0	68–0	1	0	—
							2	5	—
							3	5	—
17	(emulsion)	168–0	5–0	3–0	27–0	105–0	1	6	—
							2	15	+
							3	15	+
20	(mastic)	182–0	98–0	4–0	39–0	118–0	1	8	—
							2	0	—
							3	1	—

[1]Specimens taken from same panels from which specimens for long-term laboratory-controlled exposure were taken.
[2]Value before dash is average shear strength in pounds per square inch; value after dash is average estimated wood failure in percent.
[3]Specimens 6 by 6 inches were subjected to 15 cycles, each of 4 hours of soaking in water, followed by 19 hours of drying, both at 75° F.
[4]Tested at about 6 percent moisture content.
[5]Tested after soaking for 48 hours in water at room temperature.
[6]Tested after immersion for 4 hours in boiling water, drying for 20 hours at 145° (±5°)F., immersion again for 4 hours in boiling water, and cooling in water to room temperature.
[7]Tested dry at 160° F., 30 minutes after bringing glue line temperature to 160° F. (±5° F.)
[8]Tested at about 20 percent moisture content after 1 week at 80° F. and 90 percent relative humidity.
[9]Number of cycles to which specimen was exposed without a single delamination greater than 2 inches in length and 1/8 inch deep.
[10]According to Commercial Standard CS 35–56, Type II plywood must pass 10 cycles without a failing delamination. + means that the panel met this requirement; — means that it did not.

Table 8.—CONDITIONS USED IN PREPARATION OF YELLOW BIRCH PLYWOOD PANELS WITH RUBBER-BASE ADHESIVES, CONTROL SHEAR TEST RESULTS, AND AMOUNT OF DELAMINATION AFTER WEATHER EXPOSURE

Adhesive	Gluing conditions[1]					Control test results[2]			Delamination after 3 years of weather exposure[6] Percent
	Assembly period		Pressure P.s.i.	Temperature °F.	Press period Min.	Dry[3] test	Wet[4] test	Boil[5] test	
	After first coat Min.	After second coat Min.							
A	45	35	25	80	5	240–1	135–0	28–0	15–4
B	60	30	25	80	5	236–2	149–0	46–0	0.8
C	60	30	25	80	5	168–1	92–0	22–0	5.5
D	25	20	25	80	5	181–0	116–0	40–0	6.8
E	10	[7]3	25	200	5	248–3	105–0	27–0	5.8

[1]Veneers were spread by brushing.
[2]Value before dash is average shear strength in pounds per square inch; value after dash is average estimated wood failure in percent. Each value is average for a total of 20 specimens selected from 2 panels.
[3]Tested at about 6 percent moisture content.
[4]Tested after soaking for 48 hours in water at room temperature.
[5]Tested after immersion for 4 hours in boiling water; drying for 20 hours at 145° (±5°)F.; immersion for 4 hours in boiling water; and cooling to room temperature.
[6]Percentages of the entire bonded areas of the panel that had delaminated. Each value is the average for 2 panels.
[7]Force dried at 170° F.

Standard plywood shear specimens were cut from the trim portions of the panels at the time the panels were exposed on the fence. Equal numbers of these specimens, randomly selected, were tested: Dry; wet after soaking for 48 hours in water at room temperature; and wet after immersion in boiling water for 4 hours, drying at 145° + 5°F. for 20 hours, immersion in boiling water for 4 hours, and cooling to room temperature.

The panels have been examined annually during the summer months and the amount of glue line delamination was measured and recorded. Delaminated portions were probed with a thin feeler gage, plotted on a standard grid, and areas of delamination were computed. Table 8 includes the results of the control tests and the amounts of delamination in the panels after 3 years of exposure to weather.

The results of the control tests were approximately the same as those obtained with the newer adhesives in the present study (Table 7), and considerably lower than would be obtained for conventional woodworking glues used in plywood prepared for exterior use.

Panels made with adhesives A, C, D, and E showed excessive delamination, while Adhesive B compared favorably with hot-press urea-resin glues. In general, these panels showed two unusual characteristics not normally observed in similar panels glued with conventional durable wood glues. The edges of the rubber-base panels often had a characteristic step-wise appearance, which indicated that the adhesive bond had allowed some slippage as the face and core plies expanded and contracted unequally as a result of changes in moisture content. Also, the panels often had small boat-shaped checks, about 1/16 inch wide across the grain and 3/8 to 1/2 inch long in the direction of the grain, allowing the adhesive film to be exposed through the opening. Presumably these openings resulted from slippage of the glue line when the faces tended to check on drying during warming of drying conditions. The exposure of these panels is continuing.

Summary

Considerable variation was observed in the performance of the different rubber-base adhesives that were evaluated in this study. Generally solvent type and emulsion-type rubber-base adhesives were similar in performance except that emulsion types were definitely lower in water resistance. In comparison with other types of conventional woodworking glues, the rubber adhesives are unique in that they develop some low level of strength at room temperature immediately upon application of pressure to the joint; none of the conventional woodworking glues has this characteristic. Development of full joint strength is slower, however, for the rubber adhesives, and the ultimate level of strength is much lower than for the older wood glues. Greater resistance to water is found with many woodworking glues, but the rubber adhesives are more resistant to delamination when immersed in water than are the polyvinyl glues and the conventional hot animal glue. Polyvinyl and animal glues are capable of sustaining higher loads at 75° F. than are the rubber adhesives; however, the rubber adhesives are comparable to polyvinyl glues in load-sustaining ability at 110° F., and generally superior in this property at 80° F. and 90 per cent relative humidity.

In the present studies the solution and emulsion types of rubber adhesives differ somewhat in assembly requirements. The solution type tolerate a relatively long open assembly period, but very short assembly periods must be avoided; however, the emulsion type should be used only with a comparatively short open assembly period.

Rubber-base adhesives have a disadvantage in that they currently require application to both gluing surfaces, and sometimes two coats to each surface depending on the solids content, while conventional glues may be used generally by applying one coat to one surface only.

DEVELOPMENT OF A TAILOR-MADE

Mechanized Logging Program

HDW hauling 4-foot wood.

Vit Feller-Buncher handles full-length trees.

S. J. SIMONS
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Rugged terrain, a restless labor force, rising costs, and large inventories forced this company to assess its logging methods. Here's a case history of how it applied "Operations Research" to logging problems and came up with the program and equipment needed to improve efficiency and lower harvesting costs.

THE LIMITS OF THE QUEBEC NORTH Shore Paper Company comprise a 6000 square mile area of the Laurentian Shield based on the north shore of the St. Lawrence River between Baie Comeau on the west and Shelter Bay (Port Cartier) on the east, and reaching some 140 miles inland to the north. Eighty percent of this area is drained by the Manicouagan River and its tributaries. When the Vikings first explored the Labrador and North Shore they called this country "Markland" or Land of Forests.

This area with its abundant timber and water resources presents many natural obstacles to the exploitation of its forests. Rough, broken, rocky terrain cut deeply in all directions by rivers and streams is representative of the largest part of the area, the remainder is dotted with swamps, muskegs and infrequently, sand, gravel and glacial till.

For more than 40 years, the management of the Ontario Paper Company and later the Quebec North Shore Papers Company has carried out logging operations on the Quebec north shore, successfully combining the owner's capital, a plentiful labor supply (located on the south shore of the St. Lawrence some 40 miles away) and the rugged ingenuity of a small group of jobbers, to cut and deliver wood to the mill in Thorold, Ontario, and later, in 1937, to the new mill at Baie Comeau. The wood was cut in the fall when the men left their farms after their crops were harvested and when the heavy winter snows blanketed and smoothed out the land, horses and sleighs were used to haul the wood from where it was piled in the bush to the landings ready for the spring drive. This process, familiar to all pulpwood operators, is still the standard or conventional method of logging in Eastern Canada. Why then, you might well ask, change it if it works so well?

Why Mechanize?

As long ago as 10 to 15 years, a complex of factors was at work which lead the Company to carefully assess its future logging methods. There has been an unprecedented industrial expansion in the Province of Quebec since the end of the Second World War, much of it on the St. Lawrence north shore. The Korean War in 1950–52 resulted in built-up inventories and added momentum to the already swiftly rising cost of labor and materials. At this time, the supply of labor for woods operations began to diminish, men were leaving the smaller parishes and their farms for the challenge and adventure of big construction projects and the allure of the larger towns and cities. New job opportunities, resulting from the expansion, were obviously more attractive than cutting pulpwood. The marginal farmer began to disappear, those that were left bought small farm tractors—the horse began to disappear too. There was vigorous competition for the pool of woodsworkers that remained, labor turnover was high—the whole labor force was restless.

As costs continued to increase, the company was forced to bear a heavier burden in the form of interest charges on pulpwood inventories. The delivery of at least part of the wood production from the stump to the mill in the same year promised some relief, but such a scheme was premised on the ability to haul the wood to the driving point during the summer months.

In 1951, the general acceptance of the chain saw, and the trend toward summer cutting resulted in an increase of chopper production from 1.7 to 2.28 cords per man-day. The increase

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Table 1.—COST PER HOUR TO OPERATE HDW TRACTOR IN SUMMER

Fixed Costs:	
1. Capital Recovery ($7500, 6%, 3 yrs., 1200 hrs./yr.)	$1.67
Operating Costs Per Hour	
2. Operator	1.33
3. Gas (1.25 gal./hr. at .44/gal.)	.55
4. Oil (.28 qt./hr. at .35)	.10
5. Maintenance: Parts	2.30
Labor	1.40
Total Operating Costs	$5.68
Total Costs	$7.35

in all man-day production helped a bit, but the upward cost trend continued. Unions had already been certified on several large, nearby logging operations. Unemployment insurance to woods-workers made it almost impossible to get men after mid-December when, becoming eligible for benefits, they felt that were entitled to enjoy them.

Here were the main problems facing the Company: 1. Rugged, rocky, broken terrain; 2. A diminishing labor supply, unavailable after mid-December; 3. A diminishing supply of horses and teamsters; 4. Rising costs; 5. Large wood inventories.

The Program

The assessment of the Company's problems lead to a long-term plan that had the following as its main objectives:

1. The development of a mechanical logging system that would eliminate the muscular effort connected with all phases of the normal cutting and hauling operation and permit delivery of wood from the stump to the mill in the same season.

2. A stabilized labor force, consisting of a much smaller group of skilled and semi-skilled workers, working over an 8 to 10 month period.

Observations and time studies indicated that the main bottleneck, limiting all attempts to increase production, was in the felling, branching, bucking and piling at the stump of the 4-foot wood. This phase had to be eliminated; and it was considered that full-tree logging, using machines to replace the cutter in these operations had to be developed. The best answer appeared to be to deliver the full tree to a central yard, or processing landing, where the branching and slashing could be carried out and the concentration of trees from a large area would permit the development of suitable machinery capable of high and continuous production. A feller-buncher-yarder and a processing unit were visualized as the ultimate requirements. The development of such machines could be costly and time consuming without producing satisfactory results. It was also apparent that not all areas on the limits would be suitable for full-tree logging.

Harvesting 4-foot Logs: Thus, while the Company was able to work towards a long-term objective, there was scope for some immediate improvement in the handling of 4-foot wood. This would permit partial realization of the objectives and serve as an alternative to full-tree logging in some areas. For summer hauling, the requirement was for a track-laying machine of minimum ground pressure, relatively low capital cost, yet rugged enough to work in the rough terrain, a highly maneuverable machine capable of hauling from the stump in the summer time.

Before looking for a machine, a yardstick had to be established to measure its ability to do an economic job. Test results had to be assessed in an objective manner. In 1954, the Company engaged Mr. L. J. Lussier, a graduate forester who was writing his Ph.D. in Industrial Engineering on the application of the disciplines of Operations Research, (O.R.) to logging problems. The development and application of O.R. to forest management problems by Mr. Lussier has been one of the cornerstones of the mechanization program. Comparisons were possible between different types of equipment, and, by use of O.R., the production and operating cost of machines under development, but not yet built, could be accurately forecast from prototype trials.

In the same year, 1954, Bombardier Snowmobiles of Valcourt put out a track-laying vehicle known as the J–5. While not meeting all specifications, this machine was tried and after two seasons and considerable modification, it was accepted as a production unit. It proved that the horse could be eliminated and that delivery of wood from stump to landing during the summer was possible. However, the muscular effort required to load and unload the wood on the trailer still remained. Trials were run on a self-loading J–5 but abandoned when a more promising unit known as the M–7 made its appearance. The J–5 and trailer have, however, continued to be used as a "horse" on the operations.

The M–7 or as it was called, the Muskeg, was also a track-laying vehicle, built for the western Canadian oilfields. A tilting platform and winch had been added and it showed promise as a tree-length yarder. It was not suitable for 4-foot wood, but realizing the possibility of the basic machine, the Company co-operated with Bombardier in developing the HDW Muskeg as a 4-foot bundle yarder from the M–7. The first model was delivered for trial the end of December, 1957.

The HDW had to be tested in deep snow. With a ground pressure, unloaded, of only slightly more than 1 pound per square inch, the machine handled one-cord bundles from the stump with ease. A forecast of machine performance under summer conditions was made from production studies carried out in winter. On the basis of these results, several machines were purchased, and 39,000 cords were muskeg-hauled during the summer and fall of 1958. As expected, with any new machine, there were weak spots. All failures were carefully followed-up with the manufacturer, and sprockets, cross links, tracks and other components were modified and/or strengthened. Production and costs were encouraging enough to warrant acceptance of the HDW as a 4-foot bundle yarder. In 1959, 72,000 cords were hauled from the stump to intermediate and final landings with the HDW. A complete report, with production and costs for one company camp, titled "Mechanical Operations of Quebec North Shore Paper Company Limits" by Messrs. P. E. Pagé and A. Ross was published by the C.P.&P.A. in the February, 1960 Woodlands Review.

Table 1 shows the hourly operating cost of the HDW, which including depreciation, interest on investment, operator, gas, oil, maintenance, repairs, and rigging, amounts to $7.35. It does not include cost of choker-man or road maintenance, which would normally be another $1.40 per hour.

Table 2 gives the number of trips per hour for various hauling distances and road factors. Production in cords per hour is obtained by multiplying the number of trips per hour by the expected average load, which is normally 1 cord. Cost per cord for various distances can be found by dividing the production in cords per hour into hourly operating cost. Road factors are determined by a class description weighted by the percentage of each class on the road.

Handling of wood on a transfer haul was the subject of some study. If the bundle was unloaded directly

Table 2.—NUMBER OF TRIPS PER HOUR WITH SELF-LOADING MUSKEG IN SUMMER (WOOD WAS DUMPED ON GROUND)

Hauling Dist. Feet	Road Factor S-1	S-2	S-3	S-4	S-
	Trips Per Hour				
400	13.1	6.5	8.0	6.3	5.
600	10.9	5.1	6.2	5.0	4.
800	9.3	4.2	5.1	4.1	3.
1000	8.1	3.6	4.3	3.5	2.
1200	7.1	3.2	3.6	3.1	2.
1400	6.5	2.8	3.3	2.7	2.
1600	5.9	2.5	3.0	2.4	1.
1800	5.4	2.3	2.6	2.2	1.
2000	4.9	2.1	2.5	2.0	1.
2500	4.3	1.7	2.1	1.7	1.
3000	3.6	1.5	1.7	1.4	1.

Remarks:
1) Above figures are suitable for both short-term and long-term planning.
2) To obtain production in cords per hour, multiply the above figures by the average load; i.e. one cord in most cases.

Bombardier Processing Unit.

Table 4.—PRODUCTION IN CORDS PER HOUR WITH VIT FELLER-BUNCHER ON VARIOUS SITES

Skidding Distance (Feet)	Site Types: Hy-Co 120	Hy-Co 70	Hy-Ox 120	Call 120	Call-Co 120	Led-Call 120
	Cords per hour					
300	2.85	2.50	3.63	2.35	3.11	1.63
600	2.70	2.38	3.39	2.24	2.93	1.55
900	2.56	2.27	3.18	2.15	2.77	1.49
1200	2.41	2.07	3.00	2.06	2.63	1.42
1500	2.33	2.09	2.83	1.98	2.50	1.38
1800	2.23	2.01	2.68	1.84	2.39	1.32
2100	2.14	1.93	2.55	1.78	2.28	1.27
2500	2.02	1.81	2.39	1.76	2.15	1.22
3000	1.90	1.73	2.22	1.66	2.01	1.16

on the ground, manual loading of trucks was necessary. Direct transfer to the pallet was developed, which resulted in additional savings. Due to the limitation of load size, it was not economical for truck hauling over 6000 feet. The solution was to top load the trucks manually after the direct transfer. Four-foot bundle yarding with the HDW will likely represent an operating method in poorer stands and rougher country for some time to come. Based on performance of the HDW, it is safe to predict the horse can be eliminated at any time from the Quebec North Shore Paper Company operations.

Tree-Length Harvesting: While the HDW and J–5 solved some of the problems, the major obstacle to increased production and reduced costs, had not been overcome and the full-tree-logging system was still required.

In Ontario, the parent company, with operations at Heron Bay, had been experimenting with full-tree logging for several years. A method had been developed of feeding full trees to a chain flail, which branched and partially barked the trees and hogged the waste. The trees were then slashed and loaded directly on a truck pallet. This operation came close to success, except for a very high chain-maintenance cost. Taking a lead from this method, Quebec Division set up trials in which full trees were skidded by HDW to a 200-foot cableway. Trees chained to the wire were advanced to the slasher where the branches were taken off by a man using a brush cutter.

Table 3.—HOURLY COSTS OF OPERATING THE VIT FELLER-BUNCHER

Fixed Costs:	
1. Capital recovery (depreciation and interest) ($12,000, 6%, 3 years, 1600 hrs./year, rounded off salvage value $4,000)	$2.01
Operating Cost:	
2. Gas—(1.25 gal./hr. at .44/gal.)	.55
3. Oil—.28 qt. hr. at .35 qt.)	.10
4. Maintenance and repairs:	
a. Parts	2.30
b. Labor	1.40
5. Operator	1.50
Total Operating Costs	$5.85
Total Cost	$7.86

Vit Feller-Buncher.—A prototype of this unit was delivered for trial in the spring of 1958. With this unit, two men could fell, bunch, and forward a cord load of full-length trees to the process landing. The trials showed the machine had great possibilities, and they also indicated modifications and improvements. An improved unit was tested in the summer of 1959. With it, one man could do the work of two, in some instances surpassing the production forecast from prototype trials.

Use of the VFB which won the 1960 Canadian Pulp & Paper Association's Mechanization, results in a saving of $2.75 per cord in comparison to manual felling and forwarding by the HDW, or a similar yarder.

Table 3 shows the hourly operating cost of the VFB, including capital recovery, gas, oil, maintenance, repairs, and operator is $7.86. Table 4 gives the production in cords per hour for various skidding distances. Production varies for each type of forest site. If operating and production costs are known, however, cost per cord can be calculated for any hauling distance and type of site.

Bombardier Processing Unit: The next development was a pair of barking jaws, consisting of a necklace of steel plates with pin hinges, which can be clamped around the trunk of a tree. When closed, the jaws are held in position under hydraulic pressure and as the tree is pulled through, butt first, the jaws continually and firmly close to conform to the trunk, slicing the branches off cleanly. This was considered a major break-through in the full-tree program. Despite the simplicity of the arrangement, it worked perfectly during the preliminary trials in 1958 without any signs of wear or tear.

The process landing set-up was changed in 1958. The cableway idea was dropped in favor of a winch and a high-lead system to gain the speed and power required to pull the full tree through the barking jaws. The slasher was also rebuilt and improved. The 1958 trials were encouraging, and enough information was gathered to build a complete processing unit during the winter of 1958–59. This machine, known as the BPU, is made up of a 20-foot sections pinned together for mobility. It incorporates in a single unit the entire tree-handling system—a monorail and carriage, the branching jaw, the slasher, slasher conveyor, branch conveyor, chipper, and the conveyor to transport 4-foot wood the truck pallet. In 1959, 1,745 cords were processed by the BPU. The Company is satisfied that the basic concept is sound and that the VFB and BPU can be applied in certain forest stands, comprising 40 percent of the limits, to lower costs by $3.00 per rough cord over "conventional" methods.

The expected production of the BPU, for various stump height diameters, is shown in Table 5. The operating cost is $15.00 per hour, including capital recovery, direct material, and labor, maintenance, repairs, and cost of loading wood on truck pallets. At present, the engineering and mechanical development staff have re-designed the processing unit and a new model has been built for trial in 1960. Experiments have shown that by exerting slightly more pressure, about 80 percent of the outer bark and 50 percent of the inner bark can be stripped off in the branching process. When this facility is built into the new unit, peeled wood will come out the far end of the BPU and it could mean as much as $5.00 per cord below so called conventional methods.

Table 5.—PRODUCTION WITH PROCESSING UNIT (BPU) WITH VARIOUS DIAMETERS AT STUMP HEIGHT

DSH (Inches)	Cords/hour
5	1.06
6	1.91
7	3.10
8	4.28
9	5.17
10	5.78
11	6.27
12	6.55

[1]Computed on the basis of an 80% machine availability factor.

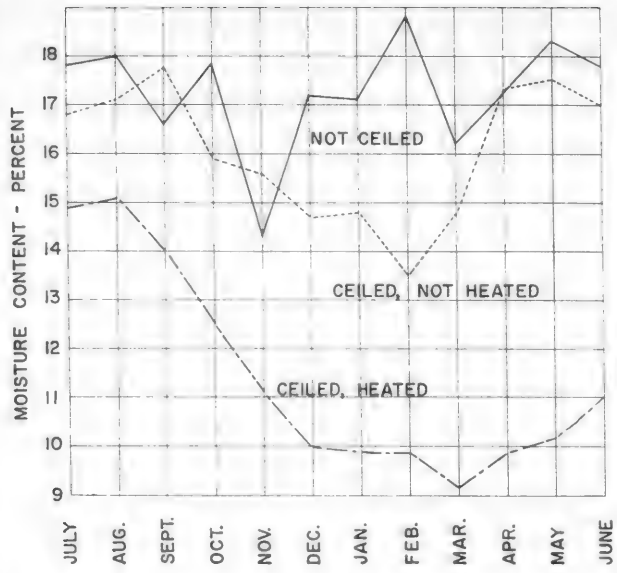

Fig. 1.—Monthly average moisture content of bottom plates, three types of buildings.

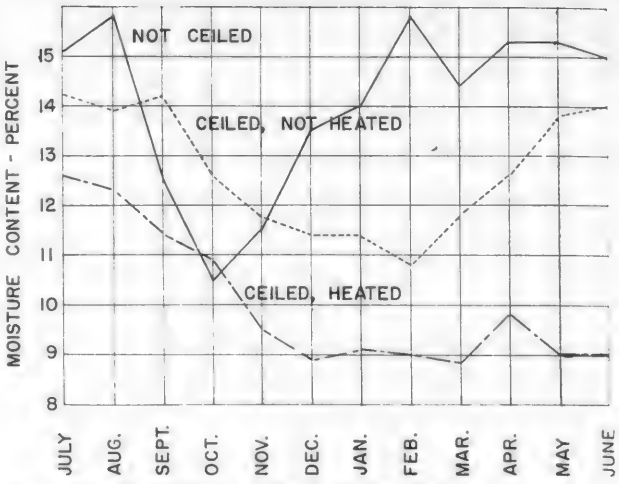

Fig. 2.—Monthly average moisture content of studs at one foot above bottom plate, three types of buildings.

MOISTURE CONTENT OF

Building Structural Members[1]

W. C. HOPKINS

School of Forestry, Louisiana State University, Baton Rouge, Louisiana

Moisture content of studs and top and bottom plates in several buildings on the LSU campus was checked for a year to determine variations due to position of wood, usage, season, etc.

THE MOISTURE CONTENT OF A PIECE OF WOOD at the time it is put into service is ignored more frequently than any other characteristic of the wood. Yet it is probably the single most important criterion of performance, because wood is a hygroscopic material—it absorbs or loses moisture with changes in temperature and humidity of the surrounding medium. Below the point where there is no free water in the cell cavities but the cell walls are saturated, wood swells or shrinks when the moisture content changes.

These dimensional changes are a constant source of difficulty for the wood user. Movable wood items such as doors, windows, and drawers tend to tighten and loosen with changes in the relative humidity of the surrounding atmosphere. Wood that is fixed in place, such as studs, joists, flooring, paneling, and door and window casings may shrink and swell enough to cause opening and closing of joints, cracking of walls, and splitting or buckling of paneling.

Attempts to stabilize wood dimensionally have been only partially successful. The processes that do seem to be satisfactory are so expensive that their application is limited to specialty items. The alternative to dimensional stabilization is to have the wood at a moisture content, when installed, which is close to the average that will prevail in the particular location. For example, interior paneling in the Baton Rouge, Louisiana, area fluctuates between 8 and 12 percent moisture content. Such paneling will give the most satisfactory service if it is installed at a moisture content about midway between these two. On the other hand, if it is a 5 percent moisture content at the time of installation, excessive buckling may occur; if at 15 percent at time of installation, shrinkage is severe and splitting may occur.

In an attempt to arrive at average moisture content values for various areas of the United States, the Forest Products Laboratory studied the moisture content of wood in dwellings in representative cities throughout the nation.[2] The information gathered in this study has been quite valuable, but it is felt that there is a need for more localized information, and also for information on specific components of buildings. A study designed to furnish such information was initiated by the School of Forestry at Louisiana State University several years ago.

Study Area

All data were collected from buildings located on the campus of Louisiana State University at Baton Rouge. Average annual rainfall here is 58 inches, which is reasonably well distributed throughout the year. The driest month is October; the wettest is July. The frost-free season averages 270 days, and usually begins about March 1. The proximity of numerous large bodies of water results in a generally high relative humidity.

The Author: William Hopkins is Professor of Forestry at LSU. He holds a BA degree from the University of Cincinnati, and MF and DF degrees from Yale University.

[1] Presented at Session XVII, Wood Drying, FPRS 14th Annual Meeting, June 5–9, 1960, in Montreal, Canada.

[2] Moisture content of wood in use. U. S. Forest Products Laboratory Report No. 1655. 1955.

Three types of buildings were investigated, not because they were typical of buildings in the area, but simply because they were readily accessible for study. All are constructed on concrete slabs, and in each case there is a sole or bottom plate in contact with the slab.

One lot of buildings is not ceiled or lined on the inside. In other words, the entire wall consists simply of the studs, exterior sheathing, and the exterior finish-wall material. This is asbestos siding in several cases and brick in several cases. There is no heat in any of these buildings. All are typical farm structures on the Agriculture Experiment Station.

Another set of buildings has walls that are lined on the inside with sheetrock so that the structural members are completely enclosed. Part of these buildings are heated during winter months, part are not heated. Two of these buildings are residences occupied by humans. No others are subjected to any use that would affect the relative humidity. No air-conditioned buildings are included in the study.

In all buildings, the bottom plate is separated from the slab by a heavy, tar-impregnated building paper. All framing material in all buildings is Southern yellow pine.

Methods of Study

Moisture content values were determined with a Delmhorst Model RC–1 moisture meter, which was fitted with a special cable with banana plugs on one end. At each location where knowledge of the moisture content was desired, two stainless steel screws were embedded in the wood to a depth of ¼-inch. The screws were placed a distance of one inch apart across the grain, insulated wires were attached to these screws with spring connectors, and were led from the screws to a panel where they were connected to a pair of jacks. Each pair of jacks was numbered according to the location of the screws, the same numbering scheme being used in every installation.

Readings were taken at every installation every other day throughout the year. All installations were grouped in a small enough area so that the readings could all be made within a period of one hour. The installations were visited in the same sequence each time beginning at 9:00 a.m. The same moisture meter was used throughout the study. At the beginning of the investigation and every three months thereafter, this meter was calibrated against oven-dried samples. The readings were adjusted accordingly and recorded as the true moisture content.

The original and all subsequent calibrations were accomplished by the use of 10 sets of end-matched samples of Southern pine 2 by 4 by 12 inches in size. The ends of these samples were coated with an end sealer to slow down any end-wise absorption of moisture as much as possible. One piece of each set of the samples was fitted with screws and wired to a pair of jacks located outside of the constant temperature-humidity cabinet. The other was weighed, and the original moisture content and calculated oven-dry weight were computed from a third end-matched sample 1 by 2 by 4 inches in size. The two larger samples were then place in the humidity cabinet and the controls set for the desired humidity. A constant dry-bulb temperature of 90° F. was used. Each day the non-wired sample was removed from the cabinet and weighed, and moisture content was calculated. At the same time a reading was taken on the matched sample with the moisture meter. When the weight of the non-wired sample stabilized, the humidity was changed. The moisture meter readings were then plotted over the calculated moisture content values of the matched samples, and the balanced curve was used as a basis for correcting the moisture meter readings.

Discussion of Results

For purposes of analysis and discussion, the data have been condensed to monthly averages and grouped by types of buildings. A preliminary statistical analysis indicated that there were no significant differences between buildings within a type. Differences between types of buildings and between locations in buildings were significant.

The moisture content of the structural members of a wall is influenced greatly by the type of wall, by position within the wall, and by the presence or absence of heat in the building. The monthly average moisture content of bottom plates resting on concrete slabs is shown in Fig. 1. The solid line represents the data from a farm-type building with no interior ceiling on the wall. In such a wall, the studs and plates are protected from direct contact with water and are shaded, but they are exposed directly to the atmosphere. In such an exposure, the fluctuations in moisture content are of greater magnitude and frequency. In addition, the range is considerable.

The data from walls that were ceiled on the inside but were not heated are represented by the dotted line. It will be noted that the maximum moisture content attained is about one percentage point lower than in the case of walls not ceiled. Furthermore, the peaks and valleys are not so abrupt.

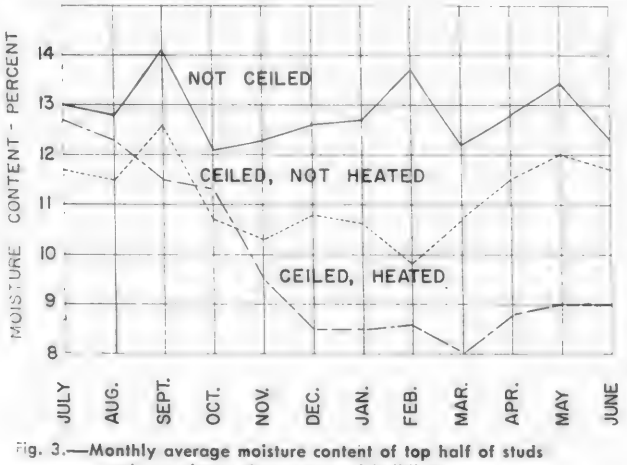

Fig. 3.—Monthly average moisture content of top half of studs and top plates, three types of buildings.

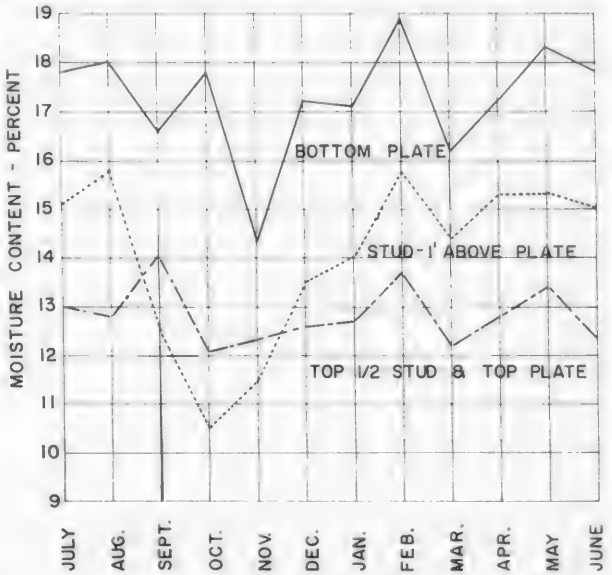

Fig. 4.—Monthly average moisture content at three locations, slab-type building, not ceiled.

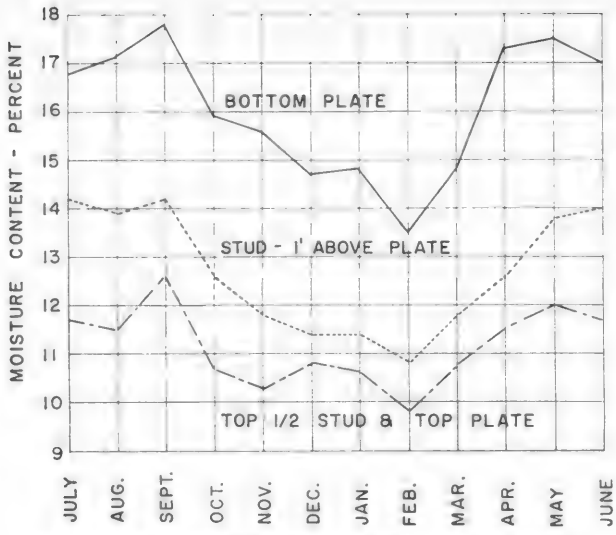

Fig. 5.—Monthly average moisture content at three locations, slab-type building, ceiled but not heated.

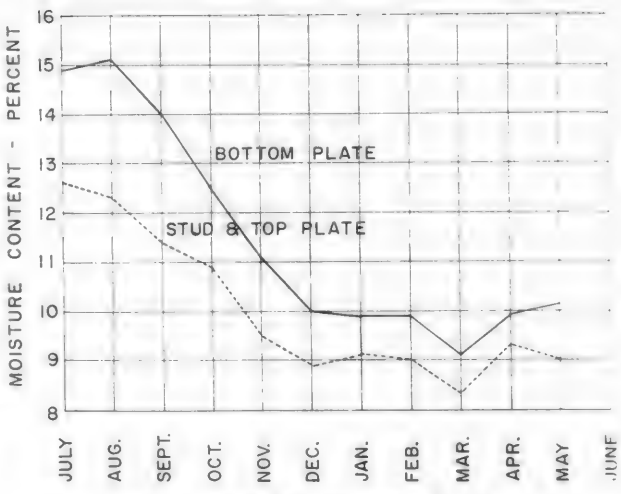

Fig. 6.—Monthly average moisture content at two locations, slab-type building, ceiled and heated.

Ceiling the wall on the inside creates somewhat of a dead air space where fluctuations of relative humidity, and consequently of moisture content of the wood, are neither so frequent nor so great.

The bottom plate in a ceiled, heated building presents a still different picture. The average moisture content during the winter months is much lower than in either of the other types of buildings. It is believed that the moisture content shown here for July and August is higher than will ever again be attained because this building had just been completed as the time readings were begun. There may have been residual moisture in the slab, and the lumber was probably excessively wet because of exposure to the atmosphere.

The average moisture content of studs, one foot above the bottom plate, in three types of buildings is shown in Fig. 2. The general trends at this location follow very closely those found in the bottom plates, with the effects of ceiling and heating virtually the same. It should be noted, however, that the entire sheaf of curves is compressed. The minimum moisture content is about the same but the maximum is somewhat less. The range of moisture content in the stud one foot above the plate is about seven percentage points, whereas in the plate it is closer to ten percentage points.

The average moisture content of the top half of the studs and the top plates again shows the same general trends, but the range is reduced further to about five percentage points. The situation at these locations is pictured in Fig. 3.

The maximum moisture content ever attained in bottom plates was 26 percent; readings between 18 and 22 percent were not infrequent. The maximum reading in studs, one foot above the bottom plate, was 20 percent with the majority of readings ranging between 13 and 16 percent. The range for the top half of the stud and the top plate was generally between 9 and 12 percent, with a maximum of 15. In all cases, the maximum occurred in the unceiled buildings. Seasonal variations are apparent on the graphs, and they follow closely seasonal variations in rainfall and relative humidity.

Comparisons of average moisture content at different locations within types of buildings are shown in Figs. 4, 5, and 6. In the not-ceiled, farm-type buildings (Fig. 4), there is a considerable difference between the moisture content of the bottom plates and the upper half of the stud and top plate. Furthermore, the fluctuations in moisture content are of greater magnitude and frequency in the bottom plates. Moisture content values in the stud one foot above the bottom plate are normally about three percent lower than in the plate, but the frequency and magnitude of changes closely parallel that found in the plates.

In the ceiled but not-heated buildings, the same general differences between locations are found (Fig. 5). Compared to the not-ceiled buildings, the range of moisture content is somewhat smaller and the frequency of fluctuation is not so great.

In the ceiled, heated building (Fig. 6), there was so little difference in moisture content of the stud in the proximity of the bottom plate and at the top that only two locations are compared. It will be noted that differences between the plate and the stud are not large, and that fluctuations in one location closely approximate those found in the other. The high initial moisture contents found in this building are believed to be due to the fact that readings were begun immediately after completion of construction. There was probably residual moisture in the slab and the wood due to exposure to the elements. Indications are that the range in this building in the future will be between 8 and 12 percent moisture content.

Conclusions

The results obtained in this study do not enable us to set hard and fast limtis of moisture content for framing material used in homes in the Baton Rouge area. It will take data from several more years before we can arrive at reliable averages. However, the data from only one year point up some interesting facts.

1. The moisture content of the wood in a house is not the same at all locations. Furthemore, one end of a relatively short piece of lumber may have one moisture content, the other end a different moisture content.

2. The highest moisture content found in this study was in bottom plates on concrete slabs. The ordinary tar-impregnated building paper used between these plates and the slabs was not an efficient moisture barrier.

3. The effects of type of wall structure, heating, and air conditioning on moisture content of the structural components need to be studied thoroughly.

4. The use of lumber that is air- or kiln-dried to 16 to 19 percent moisture content, for structural components in homes in the Baton Rouge area, is probably not good practice. Indications are that most of the structural lumber should be at a moisture content of 10 or 11 percent at the time of installation.

A NEW METHOD FOR STUDYING

The Weathering of Creosote[1]

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Applied Research Laboratory,
U. S. Steel Corp.

The weathering of creosote is analyzed by comparing evaporation patterns of small samples extracted from weathered wood and data are given on analyses of pine stakes after several years of exposure.

IN THE PRODUCTION OF METALLURGICAL coke the gases and tars driven from the coal are condensed to provide the raw material for a wide variety of coal chemicals. These coal chemicals, including millions of gallons of coal-tar creosote, are some of the important products of the United States Steel Corporation. As a major producer of coal-tar creosote, the Corporation is interested in the properties of creosote as a wood preservative, and is cooperating with the wood-preserving industry to encourage the production of creosoted wood products of the highest possible quality.

One of the best methods for studying the chemistry of creosote as a wood preservative is to extract the residual creosote from wood that has been in service and for which a completely documented history is available. For analytical purposes, however, the amount of creosote that can be extracted by conventional methods from small core borings, sections of small test stakes, and other small specimens is not sufficient. Therefore, the Corporation's Applied Research Laboratory initiated a search[2] for a relatively simple method of characterizing very small samples (0.1 to 0.5 gram) to replace the 100 grams needed in conventional E-flask distillation used by the American Wood-Preservers' Association (AWPA). The E-flask (also commonly termed the Church flask) distallation, which is accepted as the standard method for characterizing the composition of creosote, is fundamentally an evaporation method. Other methods that provide refined measurements of evaporation have been proposed by researchers at Allied Chemical Corporation and at Bell Telephone Laboratories.[3,4] These methods, however, were not well adapted to the Laboratory's problem. It was logical to reason that since the Laboratory was interested in the evaporation pattern of a small amount of volatile materials, a controlled-temperature recording balance would reveal the desired pattern. Such an instrument, a thermobalance manufactured by the Stanton Instrument Company of London, was available.

The Authors: T. W. Smeal and C. W. Leach are Junior Technologist and Supervising Technologist, respectively, for U. S. Steel's Applied Research Laboratory at Monroeville, Pa.

Stanton Thermobalance: The Stanton thermobalance, Model TR–1, shown in Figure 1, is an analytical, continuously recording balance so constructed that the sample being weighed is supported within a tube furnace. The electrically heated furnace is constructed to operate throughout a range of 1000 centigrade degrees. The temperature is automatically raised during the weighing period by means of a program-control motor. Although motors of different speeds are obtainable, the work reported here was done with a motor providing a constant rate of 6 degrees per minute temperature rise. A platinum-rhodium thermocouple located near the furnace wall at the center of the hot zone of the furnace actuates the temperature-recording pen. The furnace can be easily raised and lowered over the sample on the balance platform. The sample itself is contained in a small crucible supported on a rod attached to the weighing mechanism of the balance. A system of guide rods and counterweight keeps the furnace symmetrically aligned with the axis of the crucible.

The balance mechanism is sensitive to 1 milligram and can record a weight change as great as 50 grams. It is rapid enough to record a weight change rate of 400 milligrams per minute.

Fig. 1.—The Stanton thermobalance.

[1] Presented at Session II, Wood Preservation, FPRS 14th Annual Meeting, June 6, 1960 in Montreal, Canada; revised for publication August 25.

[2] Smeal, T. W., 1960. Use of Stanton Thermobalance for microanalysis of creosote. Presented before the American Chemical Society, Division of Gas and Fuel Chemistry, Cleveland, Ohio, April 5.

[3] Stasse, H. L., 1954. A simple fraction distillation test for creosote. Proceedings, American Society for Testing Materials, 54: pp. 1258–1269.

[4] Leutritz, J., Jr., McMahon, W., and Deeg, G. D., 1959. "Relationship of evaporation pattern and distillation characteristics of coal tar creosotes." Proceedings, American Wood-Preservers' Association, 55: pp. 165-175.

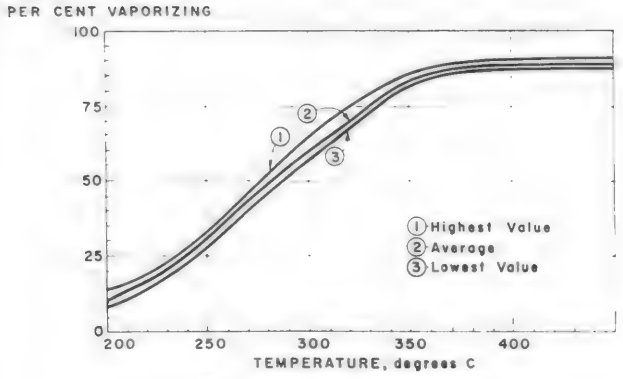

Fig. 2.—Range of results from seven replicate runs in the thermobalance.

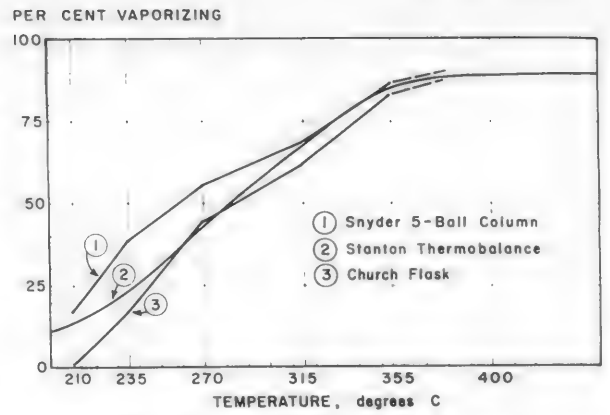

Fig. 3.—Characteristics of a creosote analyzed by three different methods.

Use of the Thermobalance: Because the temperature-recorder thermocouple is located along the wall of the furnace rather than in the crucible, a crucible of high heat conductivity must be used to minimize the unavoidable lag in the temperature of the sample. In this work a 10-cubic-centimeter platinum crucible, conforming to Standard D–271 of the American Society for Testing Materials (ASTM) was used. Experimentation with various covers on the crucible revealed that the best correlation with existing standards was obtained when the crucible was used without a cover.

The E-flask method of distillation adopted as the standard method for creosote characterization by the AWPA[5] and the ASTM[6] is basically a vaporization method because it involves no attempt at rectifying the vapors. The major difference in the results obtained by E-flask and thermobalance methods is caused by the difference in methods of measuring the temperature and weighing the distillate. The E-flask method measures the temperature at a point slightly above the liquid surface, but the distillate is not weighed until it has been collected in a flask at the end of a side-arm condenser, a distance of 52 to 55 centimeters. The weight of the distillate collected at the end of the condenser is, therefore, considerably less than the weight loss of the sample. The discrepancy is the amount of vapor and condensate retained in the flask and in the condenser. This discrepancy is particularly great during the early portion of the distillation. The thermobalance, however, continuously weighs the residue as the vapors are distilled from the sample in the crucible. The vapor loss, which is the difference in weight between the weight of the original sample and the weight of the residue, is plotted against a continuous record of temperature. The thermobalance results are not retarded and correspond more nearly to a true measure of evaporation. Plateaus or flats observed in the distillation pattern obtained by high-reflux distillation are not recorded by the thermobalance because there is no rectification of vapors, and the temperature is driven upward at a constant rate.

Developing the Procedure: The first step in developing a procedure was to determine the reproducibility of results with the thermobalance. To do this, 7 vaporization patterns were made in which replicate 0.5-gram samples of one cresote were used (Fig. 2). The range of values showed an acceptable level of reproducibility. Vaporization patterns made during any one day agreed more closely than did replicate runs made on successive days. It was believed that changes in barometric pressure, ambient temperature, and localized drafts accounted for a large part of the variation encountered.

The next step was to correlate the results obtained by use of the thermobalance with patterns obtained by use of an E-flask and by one of a Snyder 5-ball distillation column. Distillation through the 5-ball column was chosen because it is rapid and because it is used by some researchers in the field of wood preservation. The E-flask method is the accepted standard of the AWPA. The similiarities and differences between the results of these methods are shown in Figure 3. The thermobalance results generally fall between those of the other two methods. The data show that the differences between the results of the E-flask method and the thermobalance method are due primarily to the retention of vapor that occurs in the E-flask beyond the point at which the temperature is measured. Differences between the results of the 5-ball column and the thermobalance methods at attributed to the rapid rate of temperature rise (6° C. per minute) in the thermobalance. Because the loss of vapor from the sample in the thermobalance occurs as quiet evaporation instead of the agitated boiling that is characteristic of distillation methods, the rapid rate of temperature increase does not allow time for all low-boiling material to diffuse to the surface of the sample, from which it is lost. These differences are most pronounced below about 300° C.

The final step was to determine the ability of the thermobalance to detect differences in creosote composition. This was done by preparing thermobalance vaporization patterns of a fresh creosote and of distillation residues from the same creosote after distillates to temperatures of 210°, 235°, 270°, and 315° C. had been removed with a 5-ball column. Figure 4 shows the effects of removing the various fractions of creosote. It was reasonable to expect that the chemical composition of creosote extracts could be estimated by comparing vaporization patterns. To do this, the authors superimposed thermobalance vaporization patterns of the chemically changed crosotes on a similar figure made with a sample of the original creosote.

Application of the Method: To test the method on actual extracts from creosoted wood, a number of ¾- by ¾- by 30-inch stakes were removed from field-exposure plots. Duplicate stakes had been impregnated by the Rueping process with a variety of creosotes and then exposed outdoors for periods of 5 and 10 years. Stakes that were clean and free of creosote exudation were selected for the initial study. Each stake was sawn in sections as shown in Figure 5, so that indications of changes in the composition of creosote relative to its position within the stake could be obtained. These sections were shaved individually into fine chips in the specially constructed mill shown in Figure 6. The residua

[5] "Manual of Recommended Practice," American Wood-Preservers' Association, Washington, D.C., Section A1–58, p. 3.

[6] Book of Standards, 1949, American Society for Testing Materials, Philadelphia, Penna., Part 4, pp. 751–756.

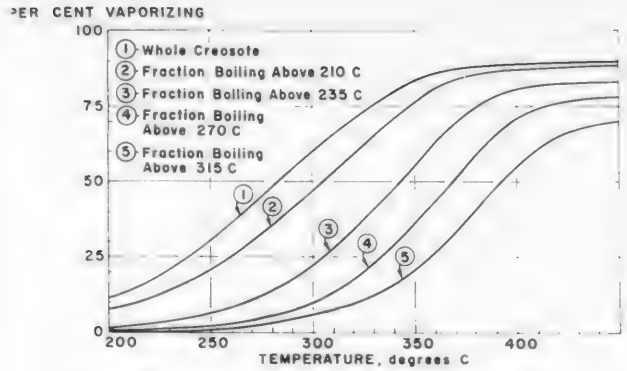

Fig. 4.—Vaporization patterns from whole creosote and 4 of its distillation fractions.

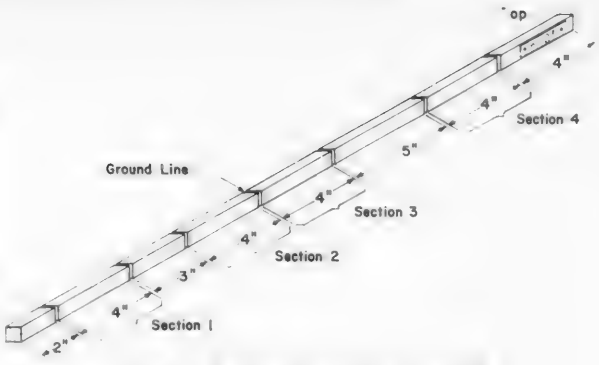

Fig. 5.—Position of sections cut from a ¾-inch square stake for extraction of residual creosote.

creosote in the chips from each section was extracted with toluene and then with pyridine solvents. The solvents were then stripped from each extract by distillation under reduced pressure.

These samples of residual creosote were characterized by vaporation on the thermobalance, and the results were graphed. To interpret these graphs, the vaporization patterns were compared with patterns of the original creosotes and with patterns of creosote residues boiling above selected temperatures.

For example, extraction of a typical stake that had been in field-exposure test for 10 years revealed that the average retention had dropped from about 140 milligrams of creosote per cubic centimeter of wood to about 60 milligrams. The thermobalance vaporization patterns for the residual creosotes from this stake show that considerable losses of the more volatile compounds have occurred on all sections of the stake (Figs. 7 and 8). It is noteworthy that the vaporization patterns for all sections generally follow the vaporization curve obtained from creosote residue boiling above 315 C. The similarity between these curves indicates that much of the creosote boiling up to 315° C. has been lost from all sections of the stake. (The differences between these curves is also significant, however, and will be discussed later.) This loss is known to occur by means of evaporation and migration. If the loss were caused caused solely by unhindered evapora- the curves developed from the extract and from the control should be very close and parallel to each other. If downward migration of part of the residual creosote had occurred, then a concentration of high-boiling material could be expected in the lower portion of the stake. Such migration can be expected to appear as a net gain (the original creosote plus the influent creosote from above) in concentration of high-boiling compenents of preservative at the lower end of the stake. This concentration was actually observed. Both below-ground sections contained about 80 milligrams of residual creosote per cubic centimeter of wood. The two sections above ground each contained less than 50 milligrams per cubic centimeter.

Furthermore, Figure 8 shows that although vaporization curves of extracts from Section 1 and Section 2 are close to the curve for creosote boiling above 315 C, the curves are not parallel. Both of these sections were taken from below the groundline. What, then, can account for the apparent differences in composition of these extracts? It is believed that soon after the test stake is driven into the ground, some of the creosote begins to migrate downward through the porous cellular structure of the wood. As it moves downward, a portion of the low-boiling volatile components is lost by evaporation from the surface of the stake. When the moving creosote approaches the moist groundline section, the downward migration is counteracted by the upward movement of moisture from the soil, by means of the wick-like behavior of the stake. In the section of the stake just below the groundline, the net effect of these counter movements causes a concentration of creosote. The creosote by now is partially depleted of low-boiling volatile components, and has a high proportion of high-boiling, relatively stable components. This concentration of high-boiling material is indicated by the relatively low position of the right end of the vaporization curve for the extract from Section 2 in Figure 8.

When the percentage of material boiling above 380 C. were converted to absolute amounts of that fraction remaining in the wood, it become evident that quantity (but not the composition) of this fraction in Sections 3 and 4 was the same as was impregnated into the wood originally (See Table 1.) Below ground, in Sections 1 and 2, where evaporation is minmized by the compact surrounding soil, the amount of this high-boiling fraction was up to twice the amount that was calculated to be in the freshly impregnated stake. This increase, which amounts be over 40 percent for the whole stake, can result only from chemical changes in the creosote itself.

Table 1.—RESIDUAL CREOSOTE BOILING ABOVE 380° C. IN EXTRACT FROM A 10-YEAR-OLD STAKE

Section of Stake	Amount (mg/cu cm)
1	43
2	52
3	28
4	29
Average amount calculated to be in stake (initial retention x percentage above 380° C. in unused creosote)	26

Fig. 6.—Mechanical mill designed to convert ¾-inch stakes to shavings suitable for solvent extraction.

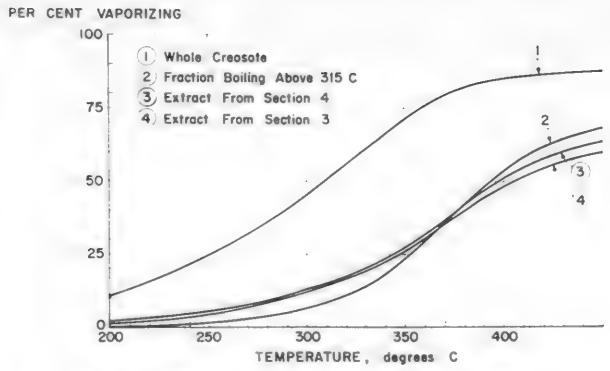

Fig. 7.—Changes in creosote resulting from 10 years of exposure in wood above ground.

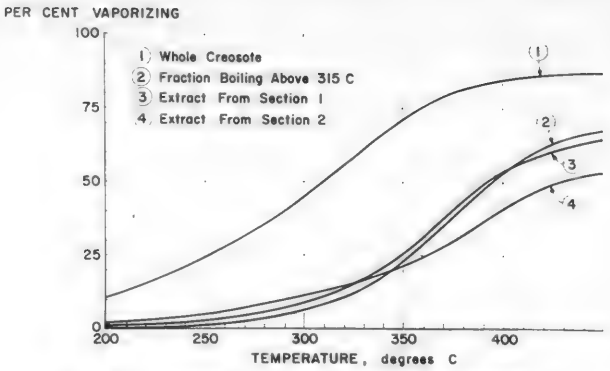

Fig. 8.—Changes in creosote resulting from 10 years of exposure in wood above ground.

These chemical changes are believed to result primarily from oxidation and polymerization reactions.

Figure 9 shows similar vaporization patterns from Sections 1 and 2 of a stake that had been in field test for only 5 years. The vaporization patterns lie between the control patterns for residues boiling down 235° and 270° C. Comparison of Figure 9 with Figure 8 indicates that evaporation of the creosote has not progressed to the extent observed in the 10-year-old stake. Because the vaporization curves closely parallel the control curves, the chemical change is believed to be relatively small.

To compare the change in composition of creosote within the inner portion of the stake with the change in creosote in the outer portion, sections extending 2 inches above to 6 inches below the groundline were cut, to remove the outer $\frac{1}{8}$-inch zone from the remaining $\frac{1}{2}$-inch core. After 10 years of exposure, 25 to 100 percent more preservative was found in the outer $\frac{1}{8}$-inch than in the inner core. If this situation occurs in full-scale utility poles and other preserved wood items of commerce, it is highly significant that the portion of the wood exposed to conditions most favorable to fungus attack is also the portion of the wood in which the preservative tends to concentrate.

When the wood shavings were extracted, it was observed that a direct correlation existed between the soundness of the stake (as rated by visual inspection) and the amount of toluene-soluble extractives. No correlation, however, was found between the condition of the stakes and the amount of toluene-insoluble, pyridine-soluble extract.

Chemical analysis of the extracts revealed further evidence of chemical changes that occurred with respect to time and position in the stakes. For example, the bromine numbers (which indicate the relative abundance of chemical double bonds) of extracts had dropped from an original value of about 13 to a range of 3 to 6 after 10 years of exposure. The greatest chemical change during exposure was observed above the groundline and in the outer zones of stakes near the groundline.

The oxygen content of residual creosote was found to be consistently higher in the outer $\frac{1}{8}$-inch zone than in the inner core. The stakes treated with a solution of creosote and coal-tar, however, had a lower oxygen content in the outer zone than in the inner zone. It is hoped that continuing work will reveal the explanation for this anomaly. Observation also showed that the toluene-insoluble, pyridine-soluble, pyridine-soluble fraction had undergone more extensive oxidation than had the toluene-soluble fraction.

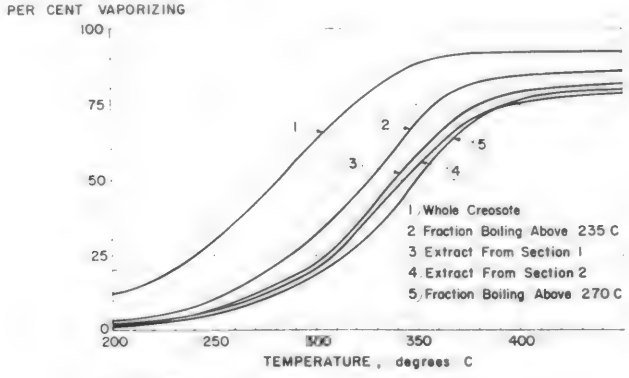

Fig. 9.—Changes in creosote resulting from 5 years of exposure in wood above ground.

Conclusion

The Applied Research Laboratory's study of the loss, redistribution, and chemical change that occurs in creosoted field-exposure test stakes during years of weathering has been aided by the development of a new method for characterizing creosote. This method, in which the Stanton thermobalance is used to characterize volatile preservatives such as creosote, has proved to be a satisfactory and reliable means of evaluating certain properties of very small samples. The continuous-vaporization pattern produced by the thermobalance is similar to that of the E-flask distillation (adopted as a standard by the AWPA and the ASTM) and that of distillation through a 5-ball column. The use of this method, in combination with other laboratory methods, has revealed that the creosote originally impregnated into $\frac{3}{4}$-inch square test stakes undergoes extensive changes in amount and in chemical composition during years of weathering. Evaporational losses and downward displacement of creosote have been shown to occur. This displacement has resulted in the concentration of creosote in the outer $\frac{1}{8}$-inch of wood near the groundline. The composition of the original preservative, however, appears to be a factor influencing the chemical changes that occur during years of weathering.

The study of evaporation patterns of relative solubility, and of the chemical properties of fresh and weathered creosote is being continued to improve methods of analysis which hopefully will aid in filling voids in the present knowledge of wood preservatives. It is also hoped that the use of these methods will increase the development of better products for the users of preserved wood.

ADHESIVES AND PROCEDURES FOR

Gluing Fire-Retardant Treated Wood[1]

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Ten years of field experience and laboratory tests have helped Roddis evolve practical methods of solving some of the problems associated with gluing fire-retardant treated wood. Here are the results of tests of nine types of adhesives the author has found suitable for use on wood treated with fire-retardant salts.

MANY PROBLEMS HAVE SLOWED the progress of the fire-retardant plywood industry from the beginning, with the result that treated material has not been readily available on the market. At the present time, several manufacturers have some glued products of fire-retardant treated wood available, but only a few have more or less complete lines of fire-retardant treated materials listed with the Underwriters Laboratory. One reason for this is that too few people have attempted to solve their own local problems.

The use of fire-retardant salts, for example, has not been widespread because difficulties have often arisen because of improperly selected treatment, machining problems, improperly selected adhesives, and inadequate or inappropriate methods of factory procedure and gluing.

The very fact that a wide variety of adhesives are available causes difficulties, because many of these adhesives are not suitable for the bonding of fire-retardant treated wood. Some of the variables that must be considered when choosing an adhesive for use on wood treated with fire-retardant salts include: 1) type of treatment, 2) amount of retention, 3) methods of treatment, and 4) grade of lumber and veneer stock.

Machining the material after treatment has also been a major problem in many cases. Wood treated with fire retardant is hard on machinery and cutting equipment. Steel planer knives and moulder knives have a short life, and sanding equipment is often difficult to use on treated stock. Carbide-tipped blades and knives are more satisfactory, but they are expensive and when the life of the blade is not long.

The methods of preparing the stock for pressing and the pressing operation have discouraged many users of treated wood because of fumes from the press and because moisture content, assembly periods, and press temperatures are quite critical. The treated stock must be machined just prior to the pressing operation to achieve the best results. Any excess salts on the surface will affect the bond. The hot-press method is a good method because of the short contact time between the adhesive and the stock prior to final curing. Another satisfactory method is to pre-glue the stock and make up the panels prior to treatment. This eliminates most bonding problems except the selection of a good waterproof adhesive. Materials that can be satisfactorily bonded after treatment are: 1) lumber of a good grade, 2) plywood, 3) phenolic-bonded particle board, 4) veneer, and 5) core stock.

The Roddis Division of the Weyerhaeuser Company has been marketing fire-retardant treated products for about 10 years. Through field experience and laboratory tests, we have evolved methods that can be used to solve some of the problems that arise in bonding fire-retardant treated stock.

The tests described here were conducted over a period of time, in fact, some of them were just recently completed. The following adhesives were used: 1) Resorcinol, 2) Phenol-resorcinol, 3) Phenolic film, 4) Liquid phenolic glued wet, 5) Liquid phenolic glued dry, 6) Melamine, 7) Melamine urea 8) Urea, high and low solids, 9) Modified urea.

These nine types of adhesive were chosen because of their suitability and for economic reasons. Other adhesives were investigated but they were eliminated because of high cost, lack of known durability, or lack of compatibility. At least two different manufacturer's glues of each type were tested. The only cold-press adhesives evaluated were resorcinol resin and urea resin. Animal glues and polyvinyl acetates were not used in these tests because they had been tried previously and were not acceptable. Emphasis was placed on water resistance and dry shear because moisture has been the main cause of failure in treated plywood. All of the resins evaluated here have proved satisfactory in fire tests to the point of being practical.

Treating Procedures

The most important part in a treating procedure is the proper selection of the material. Some species, such as white oak, yellow poplar, and some of the firs, are difficult to treat, as is the heartwood of most species. The lower grades, such as No. 1 and No. 2 common, are very difficult to treat to satisfaction. The yield is much better, and it is usually better costwise, to treat firsts, seconds and selects.

Some common methods of treatment are:

1) dipping, 2) hot and cold bath, 3) Osmose process, 4) and full-cell vacuum-pressure process. The salt retention required depends on the type of protection needed. It usually ranges from 3 to 6 pounds per cubic foot, but occasionaly it is as low as 1 pound per cubic foot or as high as 10 pounds per cubic foot. The higher the retention, the more difficult the stock is to machine and bond.

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[1] Presented at Session IX, Glues and Gluing, FPRS 14th Annual Meeting, June 7, 1960, in Montreal, Canada; revised version received for publication September 6, 1960.

The drying of water-soluble, fire-retardant treated wood is an exact procedure. Temperatures should not go over 150° F., and the drying time is quite long, up to 4 to 6 weeks on 5/4 lumber. Rapid drying will bring most of the salt to the surface. High temperature will darken the wood considerably and weaken it to a great extent. This will give a poor bond and make it unsatisfactory for service.

Machining of treated wood can cause trouble if you are not properly tooled up for it. Carbide-tipped planer blades and knives are essential for a rapid and satisfactory job. Sanding equipment can be used, but it is a lengthy operation to sand to thickness. Machining the stock to approximate size before it is treated saves time and money.

Methods of Bonding

Before the adhesive can be spread on the surface, the material must be properly machined. An excess of salts on the surface will inhibit the bond of the material. If the machined joint is too smooth, it may be difficult to get a good bond, and a smooth joint is often burned in the planer or sander and becomes very hard.

Glue spreads must be adequate on the stock to insure a good bond. If the spread falls below 30 pounds per 1000 square feet, the bond will be inferior. A spread of 37 or 38 pounds per 1000 square feet will also cause trouble. For example, a heavy spread may cause blisters, bleed-through, and inferior bonds. The viscosity of the mix is important for good application. Usually a viscosity of 10 to 15 poises is satisfactory.

The hot-press method generally produces a satisfactory bond, but, some precautions must be taken. The stock mut be kept dry prior to the application of the adhesive because of the danger of blows. A high temperature for a prolonged period will also affect the wood and the bond. There is also the danger of the volatiles from the treating salts staining the face veneer. This stain is difficult to remove except by bleaching.

The hot-press method has the advantage of a short press cycle so that the salts have a minimum time to affect the adhesive. The railing of fire doors is another operation that has certain problems. The best way to cure the adhesive in this operation appears to be with electronic equipment for high-frequency curing. This does a satisfactory job, but care must be taken to have dry stock and a low power input. The cold-clamp method can also be used in this operation.

After the press operation, it is advisable to condition the panels or doors to eliminate the possibility of warpage. The moisture of the adhesive will remain for a longer period in the treated stock than it will in untreated plywood.

Table 1.—SUMMARY OF TEST DATA[1]

	Dry Shear		Type I Shear Test	
	PSI	%	PSI	%
Resorcinol	420	90	400	75
Phenol-resorcinol	410	90	395	65
Phenol (dry)	390	70	370	40
Phenol (wet)	375	80	350	95
Urea	390	70		
Melamine	380	70	280	20
Melamine-urea	360	40	failed	
Modified urea	435	50		
Phenolic film	320	70	300	90

[1]All adhesives passed 15 cycles of the cold-soak test.

Test Methods

The tests conducted followed the hardwood plywood specifications, except that shear tests were made on all samples. Tests were (1) dry shear test, (2) cold soak for 15 cycles, (3) Type I boil tests, and (4) cold soak on door sections. The shear tests were made in accordance with the standard plywood shear test. Table 1 summarizes the results of the shear tests.

Adhesives

Resorcinol Resin: Resorcinol adhesives give a good bond either in a hot-press or a cold-press operation. They are comparatively expensive, however, and they often "bleed through" thin veneers. The partial solution to the cost is to use a phenol-resorcinol combination which also gives a good bond. The dry shear strength will be near 400 psi at the glueline, and the wood failure will range from 90 to 100 percent. Shear values for the two-cycle boil test will be slightly lower. The resorcinol and phenol-resorcinol adhesives have proved durable over a period of years in field installations of treated wood, but there still is a problem of bleed-through of the dark adhesive, especially on light colored or porous veneer.

Phenolic Resin: The phenolic film adhesives have good durability and are easy to handle. Our tests were made with a one-sheet line and a two-sheet line. The temperatures are on the high side with this type of bonding, which can cause some difficulties. With cautions, however, a very good bond can be achieved with this adhesive. The cost is moderate, and the layup requires no spreading equipment. With the two-sheet layup, there is a danger of bleed-through, but usually one sheet will suffice. The stock must have a slightly higher moisture content with this type of glue line to permit the dry adhesive to flow properly. The shear tests on this type of bond will approximate the results obtained on untreated wood. This type of bonding is obviously limited to the hot-press method, but we have no performance data on this type of gluing.

Liquid phenolic resins were treated both when pressed wet and when pressed after the adhesive was allowed to dry. The cost of phenolic resin is reasonable and the bonds are good. This seems to be about the most effective and most efficient way to bond treated materials. The phenolic resin is spread at a rate of 30 to 35 pounds per 1,000 square feet of single-glue line. A spread of less than 30 pounds will often result in skips or starved joints, while a spread of over 35 pounds may cause blows, bleed-through, and inferior bonds. The bond quality is not affected whether the assembly is pressed wet or dry. The shear-test values of treated stock are slightly lower than those of untreated veneers. This difference is small and could be caused by variations in drying temperature of the treated stock or variations in the wood. Bonds of this type have been proved in field installations of treated wood over a period of years with no failures due to poor bonds. There are some precautions that must be taken with this process besides the glue spread. With a wet bond, the stock must be below 8 percent moisture content before gluing; with dry bonding, the moisture content should be 8 to 11 percent for uniformly good bonds.

Melamine Resin: The results with the melamine resin were not as consistent as could be expected. Two types of melamine resins were tested and both were slightly inconsistent. The dry bonds and the bonds tested after the 15 cycles of cold soak were good, but in one case the test specimen failed the two-cycle boil test. The dry bonds and the cold-soak tests were comparable to panels that had not been treated. Performance tests on field installations of melamine—bonded panels have been very satisfactory. Panels bonded with melamine resins have been in service for over 10 years with no failure reported. With this resin, the bond is made with a wet glue line, but the stock must be below 8 percent moisture content for good bonding. The temperatures required are moderate so there is little effect on the treated material from overheating. Melamine adhesives are more expensive than the phenolics but they have the advantage of a light color. The melamine resins stood up well in fire tests.

Melamine-Urea Resins: Melamine-urea combinations are borderline adhesives for fire-retardant bonding. The results of the dry tests and the cold

soak test were good, but results of the Type I tests of CS 35–36 were poor. The melamine-urea combinations require a wet-bonding process with dry veneer. Here again, we have many field tests on interior installations with no failures. The melamine-urea adhesives are easy to use and offer no particular problem. They are particularly advantageous when the stock can be pre-glued prior to treating, in which case, they show very good values in all tests and good durability and excellent results in field installations.

Urea Resins: The urea resins are not too adaptable to the bonding of fire-retardant material. Here again, we have a wet-bonding operation. Both the low-solids and high-solids liquid adhesives and powdered ureas were tested, with little difference in there results. The dry-bond values were good and the results of the cold-soak tests were satisfactory. The soak tests evidently are not a good criterion of durability because there have been frequent failures in the field. This resin is easy to use and economical, but unless satisfactory cure is found, some failure can be expected in the field. The usual failure is delamination after a period of from 1 to 3 years. The modified ureas were no better than the straight ureas. Resins that are predominately urea are not too suitable of this type of bonding.

Conclusions

Fire-retardant treated stock must be well machined to insure good bonds. The reasons for this are (1) eliminate surface salts (2) have a true and smooth surface for bonding. It is a difficult bonding operation even with a good surface. Carbide-tipped knives are essential. For surface finishing a sander is satisfactory if the speed is slow and the cut quite small. The hot-press method of bonding is the most satisfactory and most widely used. This method is necessary for some of the recommended adhesives and optional for the others. The suitable adhesives are resorcinol, phenol resorcinol, liquid or powdered phenolic, phenolic, film, melamine, and in many cases melimine-urea resin. The greatest durability is shown with the resorcinol and phenolic adhesives. Before an attempt is made to bond fire-retardant treated material, a thorough testing program should be carried out to determine the proper treatment and type of adhesive required for your operation. The following test data is the average of from 5 to 8 tests taken during the testing period.

Wood Technology Training

WHERE DOES IT BELONG ?[1]

A. J. PANSHIN

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THE FACT THAT WE ARE CONSIDERing the place of wood technology programs in the institutions of higher learning means actually that we are still debating a more fundamental question: what is Wood Technology? The status of an educational program cannot be decided without first agreeing on the nature of the program itself.

Tradition is Not Enough

First of all, what Wood Technology is or where it belongs should not be based on parentage, no matter how legitimate. The priority claims based on the fact that in this country Wood Technology programs originated in the forestry schools seem quite inadequate for discussing the status of such programs in 1960 or beyond. Existing curricula reflect a surprising degree of unanimity in regard to the direction in which we are moving. But they also show that we are in a state of flux.

Wood Technology as a Science

If we take a typical curriculum in Wood Technology, such as may now be found in a number of our universities, where do we find substantiation for the claim that Wood Technology programs include sufficient emphasis on science and technology to merit professional recognition? We can find considerable justification for this contention in the fact that more and more, those who plan Wood Technology curricula are recognizing the necessity for sound basic training in mathematics, physics, engineering and to a lesser degree in chemistry, and biology, on a level that makes it possible for our students and graduates to compete on a somewhat comparable basis with other professionally trained people. At least it opens the door for the more able students to improve their technical competency by building on the foundation provided by the undergraduate curriculum.

We also find further support to the contention that Wood Technology is a science in that Wood Technology courses themselves are being constantly upgraded. More and more such courses deal with the fundamental concepts, such as wood moisture relations rather than wood seasoning, principles of adhesion in place of gluing, stress analysis and design rather than timber testing. Courses dealing with the problems of machine design and with the physical principles involved in wood cutting are replacing shop courses based on machine operation, and so on.

Graduate Student Requirements

We also find substantiation to the claim that Wood Technology is growing out of adolescence in the kind of requirements we impose on our graduate students. For instance, here are the partial requirements, outside of our own department, for two of the currently enrolled graduate students in Wood Technology at Michigan State University.

The first man is a candidate for a Ph.D. degree. His program includes theory of equations and differential equations; statics, dynamics, strength of materials and advanced strength of materials in the Department of Applied Mechanics, and a minor consisting of 6 advanced courses in statistics, which are in addition to 4 courses in statistics he took as a part of his Master's program.

The other example is that of a candidate for a Master of Science degree. His program includes differential equations, 2 courses in statistics through analysis of variance, 2 strength of materials courses in the Department of Applied Mechanics, and physical chemistry. This pattern for graduate programs is quite common now in all institutions offering advanced work in Wood Technology.

It is perhaps more self-evident that Wood Technology training is concerned with technology. When we talk about application of basic principles to plant operations, such as in seasoning, in gluing, in wood machining, or application of industrial engineering principles such as quality control, materials handling, plant organization and management to wood utilization, we deal with technology.

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[1] Part of a panel presented at Session XIV, Industry-Education, at FPRS 14th National Meeting in Montreal, June 8, 1960; received August 8, 1960.

On-Job Performance

We can of course consider the problem by inquiring about what our graduates are doing, or are expected to do, when they graduate and how well are they prepared to meet the challenges of employment. What our graduates do, lends itself to factual analysis. A number of such studies have been made in recent years and the results used to assist in developing or modifying wood technology programs in a number of our universities. What the prospective employers expect of our graduates is much more difficult to assess. What they think they want is too often motivated by the needs of the day. Some still experience difficulty in recognizing that there might be significant differences between people who come up the hard way through the ranks, and technically trained, though admittedly inexperienced, college graduates. There exists considerable evidence today that competition, technological developments, and the plain instinct of self preservation are forcing a change in attitude in certain segments of our industry, at least so that employment of wood technologists on a professional level is not longer a problem. Perhaps the more sound technical training our graduates are receiving has something to do with that, too.

From the information available to all of us about our graduates we know that most of them perform on different levels of technology, and apparently successfully. Some stray into sales and promotion work, and the more able end up in the administrative and managerial positions. A few continue with their training and enter research and teaching careers.

It seems, therefore, that Wood Technology programs are moving in the direction where the foundation of our curricula are the sciences, largely mathematics, physics and engineering and to a lesser degree biology and chemistry. On this foundation we attempt to superimpose technological training of somewhat specialized nature in that it is based on a single, but admittedly complex raw material, i.e., wood. On these two objectives we largely agree; the difference in approach becomes evident in the degree of emphasis placed on basic science requirements and the technical level on which the technological aspects of the program are presented.

Equally important is what is done with the balance of the program. Some of us think that the remainder of the curriculum requirements might be directed toward broadening the outlook of our graduates toward the economic and social problems which they will face or toward improving still further their scientific background. The others, it seems have a hard time in breaking away from the traditional requirements imposed on the Wood Technology programs by the parental relationship with the forestry schools. It is with the existence of these vestigial and traditional requirements, that there is reason for disagreement, rather than with placement of the program itself.

Where Does Wood Technology Belong?

Assuming that this analysis of what Wood Technology programs are is correct, that the basic ingredients of such programs are the physical and engineering sciences and specific technologies—where do such programs belong? At this point the question may be asked, "Where would such a program be placed in a modern university if it were conceived today and independent of real or imaginary relationship to forestry?" It would be included in the area of applied engineering.

The argument that Wood Technology should be closely linked with forestry schools because forest management students should also be exposed to wood science and technology, is not an important argument in favor of this co-existence. Certainly, foresters should be exposed to Wood Technology and wood processing. But what are the facts? How much advantage is taken at most of the schools of this availability of such instructional or re-research opportunities by the forestry majors? You know the answer. Would they be exposed any less to this area if it were offered by an applied engineering department?

On the other hand, it may also be asked, how much do wood technologists benefit from the association with other departments or areas found in our larger forestry schools? Regarded realistically, how much time should be devoted to forestry in a well balanced wood technology curriculum? Only as much as may be necessary to present a well balanced picture of our forest resources and an understanding of the economics of raw material procurement. This again can be done without a close administrative alliance between the two areas.

Are there any other benefits from this co-existence? Yes, but most of them do not stem from a mutuality of basic educational and research interests or aims, but are rather a result of the facts of life. To put it bluntly, in this country there is no other place for Wood Technology to go. Engineering schools, so far, have exhibited little or no interest in Wood Technology or Wood Engineering, and Wood Technology will never be strong enough to establish itself on an absolutely independent basis.

A Symbiosis

The answer to this problem is a symbiotic association, which in its proper connotation signifies the living together in intimate, and mutually beneficial association of two dissimilar organisms. Though dissimilar in many ways, these two areas, Forestry and Wood Technology, can be mutually beneficial provided that each is allowed to explore to the utmost its own potentialities. This can be done only if each refrains from imposing on the other restrictive requirements, based on nothing more sound than tradition. The symbiotic relationship implies among other things, an analytical approach to curriculum making. If, for instance, all the students in a forestry college must have a year of botany, or a year of calculus, this position must be defended with more sound reasoning than "of course we need botany; aren't we dealing with a plant material", or "well, I had a year of botany and have never regretted it", or, "everyone needs calculus, it is the best kind of subject to develop disciplined minds."

If our Wood Technology programs are allowed to develop on the basis of sound reasoning then the historic accident of their being a part of forestry schools can be turned to mutual advantage. But each must speak with equal authority in its respective area. Where it is not possible then either the two should be administratively separated, or the frank admission be made that Wood Technology in this case is just another "appreciation" area intended to acquaint the students broadly and shallowly about the fact that trees produce wood, and that after, all, wood is the principal economic reason why we are interested in trees. But in that case there should be no pretence that Wood Technology is aspiring to the status of a profession.

If the curriculum contents justify Wood Technology being called a science and technology program, then it does not matter where it is, and there are some sound technical and practical reasons for its being a part of a forestry school structure. If it isn't a science and technology program, but a watered down version of it, then it does not deserve to be called a professional program, and in that case, it either should be placed in a more congenial climate where it has an opportunity to grow up, or it should be treated as a back-ground, non-professional subject, intended for rounding out forest management training. In that case, it certainly should be a part of a forestry curriculum, but it should not be considered as professional training in its own right.

The Need for Emphasis on the Basic Sciences[1]

IN THE WOOD TECHNOLOGY CURRICULUM

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- **A basic science education prepares the technologist for working in a rapidly changing world.**
- **A student's years at school are the most favorable years for learning complex science.**
- **The wood technologist must be able to do more than just run a dry kiln or treating cylinder.**
- **A basic science education liberates the mind of man.**

ONE WAY TO JUSTIFY THE INCLUsion in a prominent way of the basic sciences in any program of applied education would be to extol their merits in liberating the mind of man. This argument is as old as education itself. We find it repeated even in the philosophy of the modern atom scientists. Mr. J. Robert Oppenheimer, for example, pays tribute to basic science education when he says, "The revelation of new and unexpected wonders, the harmony of a world free of inconsistency, widens us as men and gives us a sense of beauty which is both vast and robust."

This argument will seem rather remote to the everyday practice of wood technology. The technologist is more likely to be attracted by the observation that "knowledge is power." He wants practical knowledge that will assist him in finding practical answers to the problems that he must face in industry.

On the other hand, there are some who think that wood technology should go all-out for specialization in specific sciences, claiming that the best wood technologist would be a chemist, a physicist, or a mechanical engineer. This philosophy is most frequently found in the laboratory where basic research is carried on. Here it is often necessary for the research man to specialize to the point of excluding much general information needed for industrial problem-solving work.

In wood technology, as in any profession, there is room for a diversity of viewpoints, and the profession will benefit from having a plentiful supply of men who have entered the profession through circuitous routes. However, in this discussion it will be necessary to generalize and to consider the average wood technologist rather than the more uncommon specialist. Since this man will work for the wood-using industry, that industry must be examined for guidance as to what constitutes an adequate curriculum.

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The Wood-Using Industry

The wood-using industry which the wood technologist serves is, in fact, a variety of industries, having in common only this one thing, that the raw material is wood. It produces a variety of products, such as lumber, pulp and paper, veneer and plywood, posts, poles, piling, ties, timbers, cooperage, even fuelwood. Unlike the automobile industry, which is in business to make a product, the wood industries are in business primarily to use a specific raw material. They are intensely loyal to the one resource that supports them, even to the point of having segmented themselves into groups, depending upon the particular species which they may use. They do not give much thought to combining wood with other materials such as metal, plastics, glass, and the like.

Furthermore, there is considerable specialization with respect to the manner in which the resource is used. One manufacturer uses wood to make sawn products, another to make pulp, others to make veneer, flakes or particles. Large parts of the wood-using industries have not yet joined hands in integrated operations in order to use the resource to the fullest possible extent.

At least a part of this industry markets its products in a rather primitive form, sometimes without benefit of thorough drying and without much effort to improve its properties, such as by preservative, fire retardant, or stabilizing treatments. Even gluing processes, which attained their first major industrial application in the wood-using industries, have not attained general acceptance, even though many other industries—late-comers in the gluing field—are now sticking together almost everything under the sun with glue, such as shoes, automobile windshields, building components, and airplanes. Fabrication of consumer products of wood is often left to hand laborers or to small shops, not highly industrialized.

The industry is confronted by a major problem in connection with the changing nature of its resources. The species picture is changing; timber size and quality are declining. The easy-to-reach, easy-to-use woods have long been gone. The need for technical knowledge about how to use today's timber grows steadily greater.

Emphasis on Raw Material

Thus it follows that, to meet the needs of the wood-using industries, primary emphasis should be given to specialized training about the material that forms the resource for this group of resource-oriented industries. If the wood technologist is to have specialized knowledge to offer to these industries, it is this, that he has been taught certain basic things about wood that the average engineer or chemist has not been taught. This emphasis on the raw material also distinguishes him from a host of other product specialists, such as furniture technologists, paper technologists, packaging technologists, and the like.

[1] Part of a panel discussion presented at Session XIV, Industry-Education, at the FPRS 14th National Meeting in Montreal, June 8, 1960.

[2] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

This conclusion also serves to give direction to those process studies that are inevitably a part of any technology curriculum. Such studies should not be specific, and applied to particular products, dealing for example with the drying of lumber; but they must be basic and general, dealing in the drying field, for example, with wood-moisture relationships, the physical principles involved in heat transfer and moisture movement, and the anatomical and chemical properties of wood that affect drying, whether it be lumber or veneer, poles or particles.

The wood technologist must be able to do more than just run a dry kiln or a treating cylinder. Of all the technical helpers that are likely to be employed by the wood-using industries in the future, the wood technologist, if given the proper training, could become the leader who would look beyond the walls of the present industrial layout. The wood-using industry, which may initially have been slow to accept modern technological advances, is going to change, if it is not to decline. Today's greatest challenge of wood technology educators is to prepare men who will have the vision and breadth of knowledge needed by an industry facing modernization and automation.

Basic Training for the Future

This brings us to one of the strongest arguments that are frequently used in support of basic training rather than of strictly applied training: namely, in a changing world, schools cannot afford to teach a student merely how things are being done today, for they must be done differently tomorrow. A new graduate whose curriculum has been overloaded with product and process courses may have to unlearn much of what he has learned before he is of value to his employer. Mr. Robert Willis, president of the National School Boards Association, recently told a group of educators that "What we learn today is obsolete tomorrow. We must concentrate more heavily on teaching methods of inquiry, teaching people how to use tools of knowledge, rather than asking them to accept today's facts as ultimate truth."

Another argument in favor of basic education is that the student's years at school are the most favorable years for learning complex science. He is at the age where study and learning come easy. He accepts the challenge of difficult study. He is impressionable at this stage, and is easily stimulated. While on the campus, therefore, he ought to be taught those things which are more difficult or even impossible to acquire elsewhere. On the job a man can always learn how to turn valves, how to put together a machine, or how to run a quality control plan. However, once he has left the campus and is occupied with a full-time job, making a living for himself and his family, and striving to get ahead professionally, the prospects of learning the basic elements of mathematics, chemistry, or physics are dim indeed.

Where Do We Start?

Granted, then, that we are going to emphasize the basic aspects of wood technology education, where do we start? The lumber industry is the largest of the wood-using industries and it is likely to use many more wood technologists in the future. This industry, composed of over 60,000 plants and using over 50 percent of the timber cut in the United States, is one that has not changed its technology greatly in the 20th century. What do the "Golden 60's" hold in store for the lumber industry? Will the advent of new sources of energy, the new techniques of automation, change the sawmill industry? Or will it continue to chew into sawdust up to 15 percent of the material that is sawn, just to create a path for the cutting tool to move in? Should tomorrow's wood technologists be taught of the cutting action of sawteeth, or should they be taught that wood will be cut with a knife? Or shall the educator take a page from the Science-Fiction comic book, and consider the possible use of ultrasonic vibrations or some disintegrating ray? No one can tell. The information that is likely to be most useful to the candidate in the long run will therefore deal with the basic physical laws of force, momentum, velocity, the principles of electronics, the electrical properties of wood, and the effects of moisture, heat, and other variables in modifying wood during processing. It is obvious that no great improvement will come in applying the new knowledge to the conversion of wood unless the prime movers are well grounded in the laws of physics.

Interest is growing at present in the relationship between wood density and the strength and utility of the product, and how wood strength and density variations are affected by growth characteristics, geographical location, climatic factors, and the like. To deal with problems in this area, the technologist must apply basic mathematical and engineering principles. Yet an engineer alone could not solve these problems. Basic biological information will be needed: knowledge gained from the study of how wood grows, its anatomy and structure, and how its properties may vary depending on genetic and environmental conditions.

Growth of the Chemical Industry

What about chemistry? Can tomorrow's wood technologist get along with a beginner's course in general chemistry? At this point some information recently gathered by Dr Harold Tarkow of the Forest Products Laboratory will be of interest A comparison of the rate of growth of the chemical industry with that of all U.S. industry, as measured by the Federal Reserve Board Index of Industrial Production, showed that the average growth rate of the chemical industry was roughly 3 times the average of all U.S. industry. This means that the raw material requirements for this industry are increasing faster than those for any other segment of our economy.

The chemical industry can be divided broadly into 2 categories inorganic and organic. The latter pertains to the production of carbon containing materials, such as medicinals and plastics. A comparison of the rate of growth of the organic and inorganic segments of the chemical industries shows that the organic segment is growing at a rate nearly twice that of the inorganic segment At present the materials come mainly from coal tar, petroleum, or natural gas. By chemical research, means are being found for converting wood waste to industrially important organic chemicals which some day may compete with those derived from present conventional sources. The wood technologist, with a knowledge of chemistry, could be helpful in assisting the chemical industry to develop a new source of raw material, while at the same time finding new uses for the 50 million tons of wood residues per year that are generated in harvesting and using our wood crop.

Finally, there is one more argument of the practical type in favor of a basic approach in wood technology education. This one has to do with maintaining high standards of education in order to attract more than just the low-quality mechanic to the curriculum. It is known, for example, that engineering and perhaps some other disciplines are going through a program of re-evaluation with the object of introducing more basic studies into their curriculum. If wood technology curricula are not similarly strengthened, they will not

be able to attract high-quality students but will end up by attracting merely the mechanics.

Conclusion

Thus it appears that the wood technology education program could benefit greatly from more emphasis on wood chemistry and wood physics, more basic mathematics work, and a strong background in the biological sciences. It will not be necessary for every wood technologist to have a knowledge of chemistry that enables him to set up a plant to convert waste wood into chemical products, nor a knowledge of biology sufficient to grow yeast on wood sugars. However, the task of the wood technologist is bound to become more complex. In the past his task has been very elementary, because the demands of the wood-using industries have been simple. With the exception of those engaged in research and in teaching, wood technologists have been mainly practical men whose main task has been to help the wood industries to do better what they are already doing. New developments, new processes, requiring the services of wood technologists qualified to lead the industry, have not been numerous.

A tremendous program of new development lies ahead; and progress, once it begins, is likely to be rapid. At this stage particularly it is important that high-quality people be available, who may avoid making many expensive mistakes. Mr. Kappel, president of American Telephone & Telegraph, recently stated, "The cost of development is far greater than the cost of research and if a big development gets off on the wrong foot, the price is terribly high." Management, once having its fingers burned, will be reluctant to consider other new processes and developments that might prove more successful. These mistakes must be avoided by having the best technical help available.

Tomorrow's wood technologist will be capable of leading the industry to new triumphs only if he has had a thorough exposure to basic science while on the campus. Such basic training will enable him to understand the results of new research, to interpret them for management, and to develop and apply new and modern techniques in industry. He needs to have an open mind, liberated from the shackles of yesterday's and today's relatively static technology by exposure to the basic sciences, for only in this way can he be properly equipped for tomorrow's technology.

Vocational Training for Wood Technology[1]

E. SIGURD JOHNSON
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The applied approach to wood products manufacturing education is recommended as the way to train people to do what will be required of them on the job.

VOCATIONAL TRAINING IS TRAINING people to do what will be required of them on the job by applying the methods, developments, and equipment necessary. These methods and developments, the product of research people and organizations, are worked out through the application of scientific principles.

The current trend in engineering and scientific fields such as wood technology is putting more emphasis on the basic sciences and less emphasis on application and techniques. At North Carolina State College, for example, the wood technology program in the School of Forestry formerly had a curriculum that included the basic sciences, mainly mathematics, chemistry, and physics, but in addition they had specific courses in the application of these theories. These courses consisted of lectures, laboratory work, and factory visits to show how kiln drying was done, how cuttings were made, and how finishing and other technical processes were done in the industry.

Recently, this wood technology curriculum has been changed, and the emphasis has been placed on theory; courses that would not apply on as high a scientific level have been eliminated.

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More work in statistics and mathematics have been added. The wood technology program in the senior year now includes wood chemistry as a required course, and options include a number of economic courses. Some optional courses in wood products manufacturing are: economic decision processes, econometrics, economics of the firm, industrial relations, and experimental statistics for engineers. This is just an example of what is happening; these courses indicate a change in direction.

School of Engineering

Changes in the School of Engineering's industrial engineering curriculum represent what is happening in the other curricula in engineering. Formerly, students went through the basic courses in chemistry, physics, mathematics through calculus, and then they got to the typical chemical engineering design courses, such as statics, mechanics and thermodynamics, but just the minimum required to become an engineer. Then the students learned how to apply these subjects to industrial engineering problems, such as time and motion studies, production control, plant layout, and quality controls. Three years ago this program was changed and more mathematics were added. Students now take a third year of mathematics that includes, after differential and integral calculus, differential equations and an introduction to

[1] Presented at Session XIV, Industry-Education, at the FPRS 14th Annual Meeting, June 8, 1960; received September 12, 1960.

determinants. In statistics, instead of requiring one course, more courses are required including laboratory work. The industrial engineering subjects, instead of having a considerable amount of practice in stopwatch time study, have been broadened. The new courses are no longer called time and motion studies, but they cover the same ground and faster. They cover in 4 courses what they used to have in about 7. They cover the theory, but give very little application in the use of a stopwatch. It's use may be demonstrated in a laboratory, and a student may use a watch a few times but not compared to what they used to do for production control and other courses. They have gone into solving industrial problems by the use of mathematics and statistics. In operations research, the men are given the engineering theory and the mathematical theory, and they are taught to solve industrial problems by this mathematical-statistical approach. Of course, this requires more mathematical and statistical background. This is the approach that is going on in our school and I presume in most other schools.

Furniture Management Curriculum

In our furniture management curriculum, we started out to develop a curriculum specifically pointed to that one industry, which is somewhat the reverse of the trend. Our approach to the subject is directed towards turning out men who can help the furniture manufacturing industry to be more efficient. We do not promote wood as such. We are very concerned with wood on a technical basis, as is wood technology, because wood is the best material we have found for furniture. We are also concerned with upholstery materials, fabrics, springs, etc. This approach presents another series of problems. We have a 4-year curriculum and we have decided to teach the students industrial engineering, business management, a little wood technology, and special furniture subjects and still keep it at 4 years. Consequently, there was a compromise when this curriculum was set up.

This program is financially backed by the furniture industry, which has a committee that works with the college. The curriculum includes the basic sciences, but only 1 year of mathematics, which includes algebra, trigonometry, and analytical geometry. Recently we added some calculus. We have chemistry through qualitative analysis but no organic chemistry, no higher math, and physics is taught without the use of calculus, although engineering physics is normally taught with it. There are no further courses in such things as thermodynamics, engineering mechanics or strength of materials. From an engineering standpoint, this is a little weak. In the field of wood technology, we find the same situation. We started with a considerable number of wood technology courses, such as wood structure and identification and a few special courses like production engineering, structures, and construction.

The aim of the furniture program was to prepare a man to be either a technician or a manager in an industry which has very few technical poeple. Most of the furniture industry in the Southeast is made up of companies that are owned and operated by the same people. Often, one person acts as chairman of the board, president and general manager of the company; financial control is usually in the hands of the operators of the company. These operators are either men without higher education, or men with a business administration or liberal arts education. Most of the companies have no technical people, and they are not capable of putting in a proper technical program in the industry. This is why we had this particular applied program. Our graduates can go out and begin to work in the industry without instruction and do some good.

After a while, we found that these people were only an ineffective mixture. We tried to throw in a new course, such as statistics, and make our students, instead of half an engineer, three quarters of an engineer. We saw that this was not effective; we were only dabbling at the edges and not giving a man a real background.

Then, several years ago, another approach was tried—that of putting engineering on a more scientific and theoretical basis. We tried to go along with his and select those courses from the various departments that would fit our curriculum, but we have had trouble. We took the first 2 years of the industrial engineering program and put down in the budget mathematics, because theoretically, students should not be taught the use of calculus in their junior year, or more statistics until their senior year. But we found this is not true. By the time they reached statistical quality control in their third year their program involved calculus, and my students had never had calculus. The same thing, I am sure, would have happened eventually in the Forestry School, because there, the program is going in a real scientific direction. This is particularly true in wood technology, because it is intended that those people who come out with a wood technologist's degree should really know the background of wood and its complete makeup.

New Program

Now we have a new proposed curriculum. We are taking the same mathematics, chemistry, physics, as before, and the industrial engineering department still teaches some services courses in such things as time and motion study and production control. We are trying to work with forestry along the same lines

We originally required 150 credit hours to graduate, but this has been reduced to 140. This poses a problem, because there has been a tendency in our school, and I suppose in others, to add courses because you feel you can't leave something out. Our belief is that we cannot include everything in a curriculum and teach it well. What we have done is to reduce some of the industrial engineering subjects, and we have suggested reducing some of the wood technology. What are we trying to do in our program when we do this? A man doesn't have a really complete engineering background, let's say, judging from our particular curriculum, and neither will he cover his wood technology background in detail. However, we do have some application courses.

The final examination in a course in furniture manufacturing and processing represents the approach to this subject. This exam does not merely test the student's knowledge of the course, it determines whether the student was able to analyze and solve a problem. The 4-hour test involves the design and layout of a plant to produce a given amount of a certain price-level furniture.

In the 4 or 5 years available to train students for work in the industry, we just can't crowd in all the subjects and courses we would like to. Some things have to be omitted. We give our students a little of the basic sciences and wood technology but not a thorough understanding of them. Bear in mind, however, that we are turning out men who can be used in the next 10 years. Since we cannot be all things to all people why not do the job that we can do —and do it well.

Wood Technology in the Forestry Schools[1]

G. A. GARRATT
Yale University, School of Forestry

The wood technology curriculum should be geared to training specialists qualified both for technology positions in development and research and for production and supervisory work in the forest products field.

IT IS NOT MY INTENT TO PARTICIPATE in a debate on a single appropriate home for education in wood technology, but rather to point up my conviction that the forestry school is a logical, but in no sense exclusive, sponsor for the continued development of wood technology training.

In the interest of a more orderly consideration of where the indicated training belongs, or how it fits into one type of school or another, it is desirable to offer a definition of wood technology. I appreciate that I am in an area of high disagreement potential, and am not prepared to offer a comprehensive and all-inclusive definition that will satisfy all customers, any more than I am prepared to define "forestry" as we conceive it today.

The classical concept of wood technology as introduced in the forestry school curriculum 40 years or more ago, was that of a course in wood structure and identification—later expanded to include physical properties. It is interesting to note that today a fair number of schools with major offerings in the area under consideration have a specific course labeled wood technology with these same subject matter limitations—and generally distinct from another course designated as timber machines, timber physics, or mechanical properties of wood.

Expansion from a course to a curriculum, in the evolution of a program of study in wood technology with or without several optional specialties, has been quite diversified in the various forest schools. As a consequence, we find a basis of disagreement between administrators of wood technology programs and even among members of their faculties, not only in regard to where the basic instruction should be seated but even more so with reference to what constitutes an adequate program of study in the light of present-day needs and opportunities.

What is Wood Technology?

For the sake of something to tie my discussion to, I am accepting the definition in the latest edition of *Forest Terminology*, published by the Society of American Foresters, which refers to wood technology as the science of wood, including its anatomy, chemistry, properties, and treatment. In conformance with my interpretation of this definition, I am excluding from my consideration such applied phases of wood utilization as furniture manufacturing, lumber merchandizing, pulp and paper manufacturing, packaging, and other subjects of this general type.

Traditionally, education in wood technology and companion instruction in general wood utilization have been conceived and nurtured as definite aspects of the forestry school program and brought to the present state of admittedly imperfect development under such sponsorship.

It is conceded that wood technology, as we understand it today, in its broad sense might well have been developed, with somewhat different emphasis, in our schools of engineering, schools and departments of chemistry and chemical engineering, technical institutes, or faculties of applied science. In a real sense, these and other potential sponsors have let the opportunity to direct the direction of wood technology education go by default—largely because of their notable lack of interest in wood other than as an incidental engineering material or chemical material.

Forestry Sponsorship

We all recognize the great contributions made in the field of wood technology by engineers, chemists, physicists, mathematicians, and others outside the profession of forestry, but at the same time we must also give recognition to the work of wood technologists with a forestry background. It is interesting to note in the recent listing of "professional education programs for careers in the forest products industries" that instruction in wood technology and utilization is offered at 25 institutions—and in every case under the exclusive administration of the school or department of forestry or conservation. This is exclusive of such programs as building construction, furniture manufacturing, pulp and paper technology, and wood products merchandizing, which in some instances are taught in other departments.

Also worthy of note is the fact that, almost without exception, the direction of the recognized wood technology and utilization programs is in charge of men who received their training in our schools of forestry. Furthermore, we can point with pride to the growing number of men with forestry school backgrounds who are in charge of research and development for companies in the forest industry field. Development of the major educational labs concerned with research in wood technology has been largely in association with forestry schools. Of the 11 first place Wood Awards made since that competition started, all but one have been to students enrolled in forestry schools. In the 1960 competition, the overwhelming proportion of the papers submitted was from such students. The diversity of the subjects and the basic nature of most of the studies involved provide a clear-cut indication of the attention the for-

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[1] Part of a panel presented at Session XIV, Industry-Education, FPRS 14th National Meeting in Montreal, Canada, June 8, 1960; received July 29, 1960.

estry schools are devoting to instruction and associated research in wood technology.

If the proof of the product is in its performance, I contend that the programs which have been developed under forestry school auspices are demonstrating their worth.

Future Development

There are three main avenues of approach to the further development of instruction (and associated research) in wood technology: biological, engineering, and through the physical sciences—each with its particular advantages and values. Actually, of course, associated training transcends the normal boundaries of these three areas, with its concern with math, economics, business administration, communications, and other areas of instruction. Short of a virtual lifetime spent in school, the training of a wood technologist is bound to represent a compromise in subject coverage, dictated by the interest of the student and the concepts and requirements of the educational institution.

Accepting the fact that the biological approach to wood technology is a logical and normal one, especially in dealing with a material that is biological in its origin, my contention is that such instruction is a definite responsibility of the forestry school, with its vital interest in the production, harvesting, and utilization of wood as a major product of the forest. In that setting, the wood technology curriculum should be geared to training specialists who are qualified (within the limits of their academic experience and their further self-education) both for technology positions in development and research and for production and supervisory work in the forest products field. Some schools may emphasize the research and development objective, especially at the graduate level; others the production and supervisory aspect; while still others may combine the two objectives.

Needed: A Flexible Curriculum

The opportunities for further development of wood technology in our forestry schools point up the need for a marked degree of flexibility in the curriculum, liberalizing the program of study to provide more adequately for requisite courses in math, basic sciences, and engineering, yet at the same time retaining a minimum of pertinent courses in forestry—dendrology, applied silviculture, forest economics, for example—in order to provide the wood technologist with at least a limited perspective regarding the management and significance of the timber resource. Such a development has, of course, been underway in more than a few of our forestry schools for some time, with more than minimal success. The main points of argument have come in establishing the degree (or extent) of departure from a core of forestry subjects, and in deciding on the extent of diversification and specialization in the program.

The time limitation of the 4-year undergraduate program is an obvious major problem in the development of a suitable curriculum in wood technology, especially if our concern is for educating superior students for a profession rather than training men merely for a vocation. It is obvious that students cannot be educated properly in all aspects of wood technology or perhaps adequately even in one area in the span of four years. This is a circumstance which focuses attention on the significance of graduate study as a part of the wood technology program. It also emphasizes the significance of continuing self-education.

In the forestry school, the wood technology program can make a second important contribution in addition to educating specialists in that field. This is in providing appropriate instruction dealing with relevant basic aspects of wood technology for the forest management major, silviculturist, geneticist, and other specialists as well as the generalists in forestry. It is important that these men have an adequate understanding of the material they are engaged in growing, so that they may more effectively direct their efforts toward controlling the quality of timber and meeting the requirements of the forest industries. In this capacity, wood technology will serve to bridge the gap between those who grow the timber and those who utilize it.

Let's face our real problem. We are not attracting enough fresh blood into the industry through the available educational channels, and we are not fully utilizing the facilities of our schools. The product coming out of our present wood technology program is selling itself—our graduates are becoming more and more acceptable to the forest industries. But, we must continue to place the emphasis on quality of instruction and quality of student. Let's not worry about where the job is done—let's concern ourseves with developing all the outlets we can.

Bumps and Dents on Lumber

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Forest Products Laboratory,[1] Forest Service
U. S. Department of Agriculture

EVERY NOW AND THEN SOMEONE SENDS to the U.S. Forest Products Laboratory a sample of lumber with a puzzling bump that appeared mysteriously on the smooth surface.

An excellent example of these strange bumps is shown in Figure 1. The wood is Douglas-fir of an extremely light, slow growing type with 60 rings per inch, the sort of wood that comes from the outside of big, old, over-mature trees.

This bump was sawed in half as shown in Figure 1. Part *A* shows the character of the bandsawed surface, with toothmarks plainly showing on all slopes. Part *B* shows the profile. Measured at the peak of the bump, the sample is ⅝ inch thicker than at the base. Since big bandsaws leave flat surfaces, it naturally follows that the original board was flat when it was freshly sawed and the bump developed afterward.

A somewhat elastic substance, wood can be compressed and, after the compressive force is removed it can recover its original size. Somewhere in the handling operations, the log from which the sample (Fig. 1) was obtained sustained a blow heavy enough to compress the soft green wood to a depth at least equal to the height of the bump. The board under discussion was sawed off very shortly afterward. The compressed wood in this board gradually expanded and recovered its original position to a large degree at least: This expansion produced the bump, like a little round hill, plainly showing the bandsaw marks on all its slopes.

Figure 2 is presented in support of the above explanation. In this piece of dry ponderosa pine, three dents of equal depth were deliberately made at points *A*, *B*, and *C*. The wood under these dents, of course, is compressed

[1] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

none was removed. One of the original dents remains at *A*. A jointer cut was made just deeply enough to remove the dents at *B* and *C*. The surface at *B* is just as the jointer cut left it; no dent, no recovery, but some slight evidence of compression. Water was applied at point *C*, and within a few minutes the compressed fibers beneath the original dent recovered and produced a small bump as shown. Prolonged exposure to high humidity can be expected to produce similar results at *B*.

This water test has a practical application if a question arises as to whether small depressions are chipped grain or chip marks. Water will have no effect on chipped grain, because particles are actually broken out below the line of cut, as shown in Fig. 3,*A*. The wood in this figure is birch. Chip marks, on the other hand, are small depressions where the wood has been compressed rather than removed. They are caused by chips that occasionally fail to pass off in the exhaust but cling to the knife edge and dent the wood on the next revolution. A rather extreme case is illustrated in Figure 3,*B*. The result of applying water is demonstrated in Figure 3,*C*; here the compressed wood in the dents has expanded, changing depressions into small bumps. Wood specimens *B* and *C* in Figure 3 are Sitka spruce from the same board.

The peculiar pattern of low bumps in Figure 4 occurred regularly at 19-inch intervals along the length of a 12-foot board of ponderosa pine, one of the softer and more compressible species. The moisture content at the time of machining was not known, nor was the method of storage after planing.

Six inches is a common diameter for outfeed rolls in planers. In round figures, this means a circumference of 19 inches, which equals the spacing of the bump pattern. Deposits of glue or pitch allowed to set on the outfeed rolls can imprint patterns at uniform intervals on planed lumber. This condition, followed by moisture pickup, is believed to explain the origin of the bumps in Figure 4.

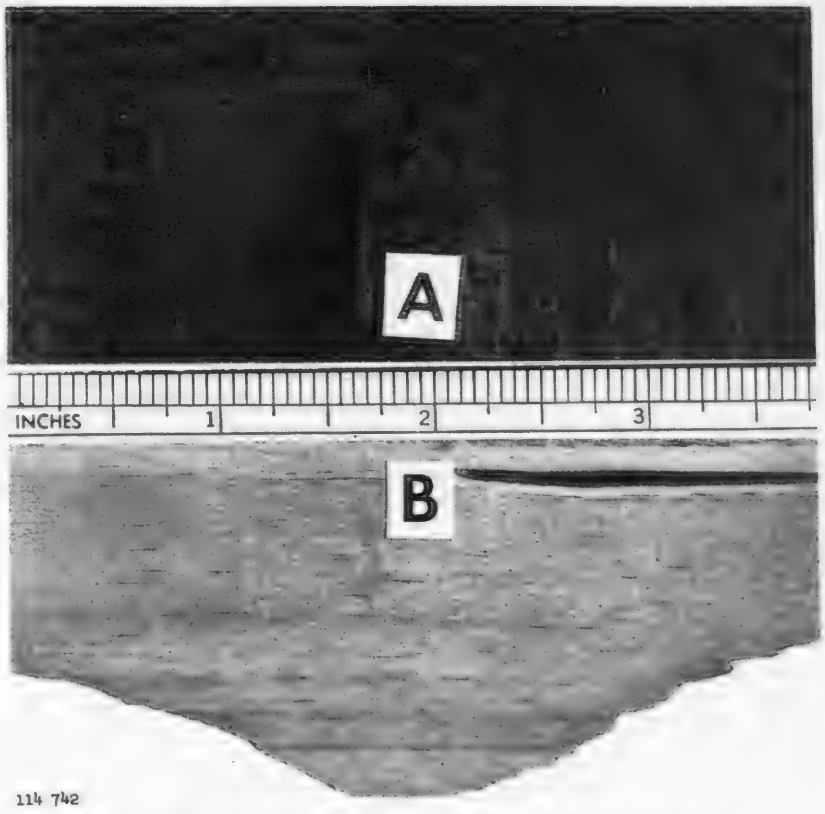

Fig. 1.—Unusual bump on a Douglas-fir board; A, surface of bump showing sawmarks on all sides; B, profile of bump.

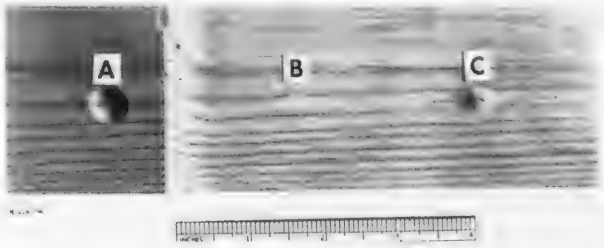

Fig. 2.—Method of producing small bumps in the laboratory or shop. Point A, type of dent originally made at A, B, and C; B, dent removed by jointing; C, dent removed by jointing and bump produced by applying water.

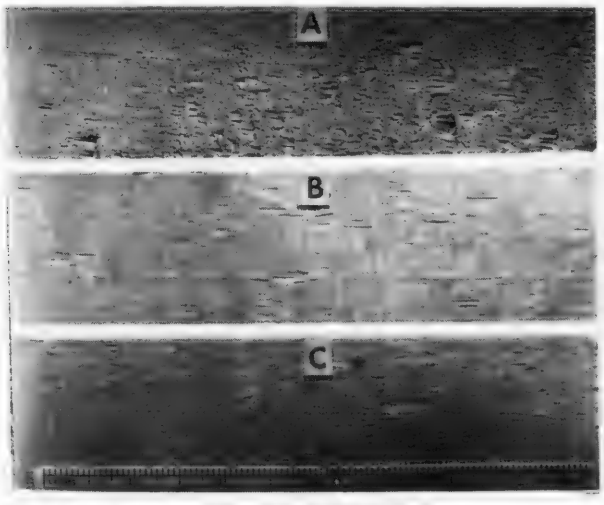

Fig. 3.—Distinction between depressions caused by chipped grain in birch, A, and chip marks in Sitka spruce, B. In C., application of water.

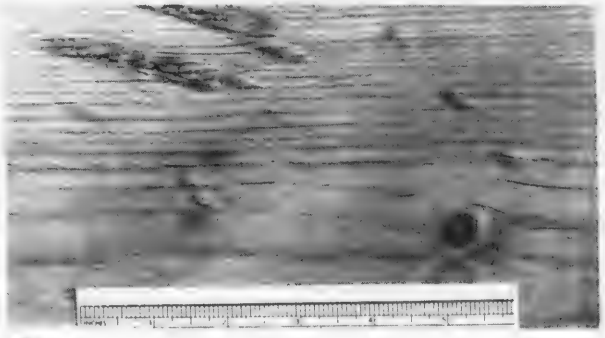

Fig. 4.—This pattern of bumps recurring at 19-inch intervals throughout length of board was caused by deposit of glue or pitch on outfeed rolls of planer.

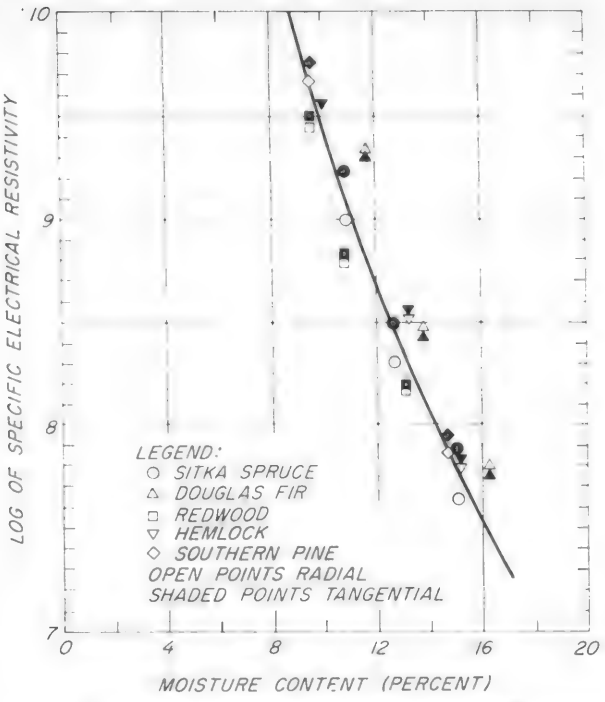

Figure 1.—Relationship between the logarithm of the specific electrical resistivity of five softwoods and the moisture content.

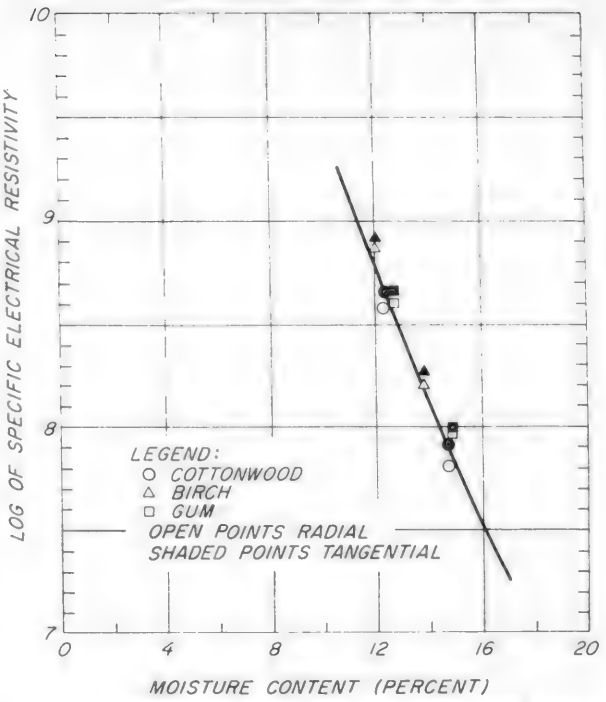

Figure 2.—Relationship between the logarithm of the specific electrical resistivity of three hardwoods and the moisture content.

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Bound-Water Diffusion Into

FPRS HONORARIUM SPEAKER

IN A PREVIOUS PAPER THE AUTHOR (12)[3] developed a method for determining the continuous bound-water diffusion coefficients of wood in the fiber direction. The vapor phase portion of normal moisture movement through wood was eliminated by filling the microscopically visible void structure with a molten metal containing bismuth, which causes the alloy to expand slightly on solidification, thus sealing off the capillaries. Measurements were made of the rate of water adsorption and swelling by these thin metal-filled cross sections at various relative humidities and when immersed in liquid water. It was shown that diffusion coefficients can be calculated from both the rate of water adsorption and the rate of swelling data. The two methods gave values in good agreement. Measurements made in liquid water on eight species of wood showed that species variations and differences between heartwood and sapwood are small for woods low in water-soluble extracts. Extractives were shown to act as bulking agents, increasing the rate of diffusion as though the measurements started at a higher moisture content. The average bound-water diffusion coefficient for continuous diffusion in the fiber directions is 40 $\times$ 10^{-8} cm.^{2} per sec. for softwoods low in water-soluble extractives and 46 $\times$ 10^{-8} cm.^{2} per sec. for hardwoods. Measurements made on Sitka spruce cross sections under different relative humidity conditions showed that the bound-water diffusion coefficient increases exponentially from a very low value at 4 to 6 percent moisture content to quite a high value at average moisture contents approaching the fiber saturation point. It was also shown that the bound-water diffusion coefficient in the fiber direction increases rapidly with an increase in temperature at a rate about proportional to the increase in vapor pressure. This indicates that the movement of bound water is not a mass movement but rather consists of a series of molecular jumps which are vapor pressure controlled (12).

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Because of the fact that lumber is normally very long in the fiber direction compared to its dimensions in the radial and tangential directions, the major part of drying occurs across the fibers. It is hence of importance to obtain bound-water diffuson coefficients in the transverse directions if they are to be used in calculating theoretical drying rates.

Ratios of Bound-Water Diffusion Coefficients in the Transverse Directions to the Fiber Directions From Electrical Measurements

The author (11) has shown that diffusion through a complex system of paths in parallel and series combination is analogous to electrical conduction through the same system. Diffusion through a number of paths in parallel is additive. Diffusion through a number of paths in series is the reciprocal of the sum of the reciprocals of the diffusion through each individual type of path. This analog was confirmed by Burr and the author (2) for wood completely filled with a salt solution by showing that the transverse electrical conductivit

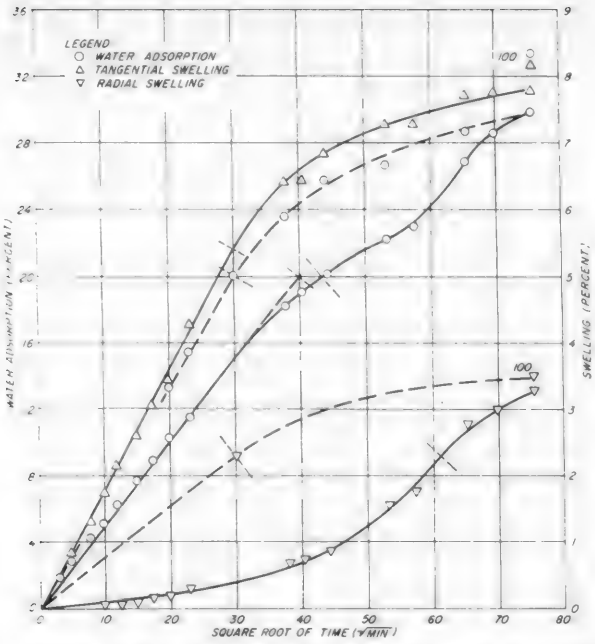

Figure 3.—Rate of water adsorption and swelling of a metal-impregnated thin specimen of Douglas-fir in the tangential direction. Solid lines show experimental values; dashed lines show stress-free calculated values; cross dashes are drawn at ⅔ of final values. Numbers at right indicate final time.

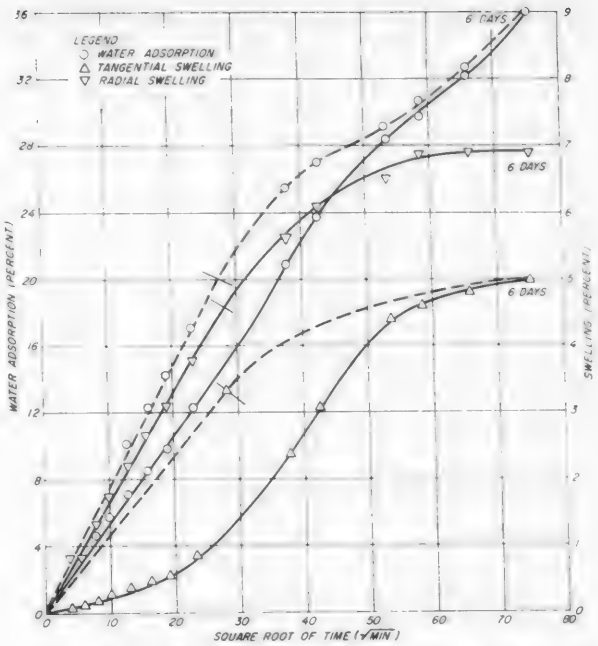

Figure 4.—Rate of water adsorption and swelling of a metal-impregnated thin specimen of Douglas-fir in the radial direction. Solid lines show experimental values; dashed lines show stress-free calculated values cross dashes are drawn at ⅔ of final values. Numbers at right indicate final time.

Wood In Across-The-Fiber Directions[1]

relative to that of the bulk solution of the same dimensions is virtually equal to the diffusion coefficient of salt into matched water-filled specimens relative to the diffusion of salt in bulk water (2).

It was felt that this same analogy should hold for bound water in wood below the fiber saturation point. If this were the case, the ratios of the electrical conductivities through a block of wood at any particular moisture content below the fiber saturation point in the tangential to the fiber direction should be equal to the ratio of the diffusion coefficients for bound water through the cell walls in the same directions.

Although there is considerable data in the literature for the electrical conductivity of wood (3, 4, 5, 8, 9, 10, 5,) the only publication found that gives specific conductivities in the

Diffusion coefficients were obtained from 1) electrical conductivities of wood in the transverse directions and 2) bound-water diffusion coefficients in the fiber direction. Direct measurements were also made. Calculated and measured values were in good agreement.

three structural directions from which the desired ratios can be calculated is one by Hiruma (5). He gives ratios of radial to longitudinal conductivities for three softwoods ranging from 0.31 to 0.49 and for five hardwoods ranging from 0.26 to 0.45. The corresponding tangential to longitudinal ratios range from 0.28 to 0.42 for the softwoods and from 0.16 to 0.26 for the hardwoods. As none of the species used in this research were included in the research of Hiruma, it was decided to make electrical conductivity measurements on blocks of wood cut from the same specimens used for determining the bound-water diffusion in the fiber direction (12).

The measurements were made on cubes of eight different species that were conditioned to three different moisture content conditions using a modification of the mercury contact method of Hiruma (5). This was preferred to the electrical conducting silver paint contacts used by Davidson (3), as the measurements can be made in all three structural directions on a single block of wood. Weighings, dimension measurements, and the rate of attainment of equilibrium moisture content are not affected by the mercury contact.

A cup is formed on one face of a specimen by wrapping 0.5-inch-wide electrician's tape around the edges so that about 0.25 inch protrudes. The

[1] The fifth of a series of seven reports of damental studies on moisture movement in od. Essentially, the information contained in series was the basis for "Fundamentals of isture Movement in Wood," the "Honrium Lecture" sponsored by the Midwest tion and presented by Dr. Stamm at the National Meeting June 6, 1960 in Mont-Canada.

[2] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

[3] Numbers in parentheses refer to Literature Cited at the end of this article.

Table 1.—SPECIFIC ELECTRICAL RESISTIVITY OF SITKA SPRUCE CUBES IN THE THREE STRUCTURAL DIRECTIONS AT THREE RELATIVE HUMIDITIES

Specimen No.[1]	80 percent relative humidity: Moisture content Percent	Specific resistivity Megohms	Ratio of resistivities	65 percent relative humidity: Moisture content Percent	Specific resistivity Megohms	Ratio of resistivities	50 percent relative humidity: Moisture content Percent	Specific resistivity Megohms	Ratio of resistivities
1-L	14.9	22.8	1.0	12.7	104	1.0	10.8	541	1.0
R		44.1	1.93		198	1.91		981	1.82
T		73.7	3.23		321	3.10		1,760	3.26
2-L	14.9	24.0	1.0	12.7	106	1.0	10.8	536	1.0
R		46.8	1.95		197	1.86		981	1.83
T		74.8	3.12		322	3.04		1,760	3.23
3-L	15.1	22.7	1.0	12.8	108	1.0	10.9	538	1.0
R		43.5	1.87		200	1.85		980	1.82
T		70.0	3.08		319	2.96		1,735	3.23
4-L	15.1	23.1	1.0	12.9	108	1.0	10.9	532	1.0
R		43.2	1.87		205	1.90		974	1.83
T		72.4	3.13		318	2.95		1,725	3.24

[1]Nos. 1 and 2, 2.25 inches on a side. Nos. 3 and 4, 1.75 inches on a side. L longitudinal flow of current, R—radial flow, T—tangential flow.

specimen is held with the cup surface horizontal in a high electrical resistance clamp. A dish containing mercury is slowly raised on an adjustable table by means of a fine screw adjustment to almost contact the bottom of the specimen. The specimen is adjusted in the clamp so that the clearance above the mercury is the same around all of the bottom edges. The table is then raised so that the mercury just makes contact with the block of wood. Mercury is added to the cup to a depth of about 1/8 inch. Electrical contacts are then made with the mercury in the cup and in the lower dish to an electrical resistance bridge circuit.

The bridge circuit consists of a high known resistance, S_1 (approximately 1, 5, or 20 megohms), a variable resistance box ranging from 1 to 11, 110 ohms, V, a standard resistance of 1,000 or 10,000 ohms, S_2, and the wood specimen with an unknown resistance, X. An electronic electrometer is connected between the junctions XS_1 and S_2V. A potential of 45 volts in series with a tapping key is connected across the junctions XS_2 and S_1V. The resistance of V is varied until no deflection occurs on the electrometer when the key is momentarily depressed.

What This Research Means

Theoretical studies of the mechanism of the movement of water through wood have been hampered by the fact that three different types of movement can occur simultaneously. A method for measuring bound-water movement through the fibers independent of liquid and vapor movement in the coarse capillary structure has been worked out and experimental diffusion coefficients determined in the across the fiber directions. The way in which these can be combined with vapor diffusion coefficients to calculate the combined diffusion will be given in the next paper of this series. It is felt that these fundamental studies will eventually lead to improved methods for drying wood.

Duplicate readings are readily made by lowering the table to break the contact and again raising it to just make contact. Table 1 gives the data for four Sitka spruce cubes of two sizes determined at the equilibrium moisture content at each of three different relative humidities. The fact that the two sizes of cubes give comparable specific resistivities indicates that Ohm's law is obeyed. Although the resistivities increase greatly with a decrease in moisture content, the ratios of the resistivities in the radial and in the tangential to that in the longitudinal direction are virtually unaffected by changes in moisture content. Table 2 gives the ratios of the conductivities (the reciprocal of the ratios of the resistivities) for the eight species of wood. Although the ratios vary appreciably between species, they all fall in the range of 1/4 to 1/2 and are quite similar to the values given by Hiruma (5). Figure 1 shows a plot of the logarithm of the specific electrical resistivity in the radial and the tangential directions against the moisture content for the five soft woods. Figure 2 is a similar plot for the three hardwoods. The slight curvature of the plot is in good agreement with the plot of the logarithm of the specific resistivity versus moisture content published by Weatherwax and Stamm (15) for wood with the ring at various angles.

The ratios of tangential to longitudinal, and radial to longitudinal, conductivities of Table 2, representing the ratios for the bound-water diffusion coefficients, were used to calculate the tangential and radial bound-water diffusion coefficients given in Column 5 and 8 in Table 4. These will be compared later with coefficients derived from water adsorption and swelling data.

Rate of Bound-Water Diffusion in the Transverse Directions in Metal-Impregnated Wood

Thin edge- and flat-grain specimens of three different softwoods and three hardwoods (about 1/8 inch in the tangential or the radial directions by 2 inch square in the other directions) were cut from the same stock specimens as the cross sections used for determining the bound-water diffusion coefficients in the fiber direction (12) and the cubes used in the electrical measurements just described. The specimens were ovendried, weighed, and

Table 2.—AVERAGE RATIO OF RADIAL AND TANGENTIAL SPECIFIC ELECTRICAL CONDUCTIVITIES TO THAT IN THE LONGITUDINAL DIRECTION FOR DIFFERENT WOODS

Species	Specific gravity[1]	Number of: Specimens	Sizes	Relative humidity conditions	Ratio of conductivities: Radial-longitudinal	Tangential-longitudinal
Sitka spruce	0.38	4	2	3	0.53	0.32
Douglas-fir	.55	2	1	3	.40	.42
Redwood	.44	4	2	3	.50	.48
Western hemlock	.55	2	1	3	.51	.48
Southern pine	.53	2	2	2	.36	.30
Paper birch	.62	2	2	2	.31	.27
Sweetgum	.52	1	1	2	.31	.26
Black cottonwood	.29	1	1	2	.35	.27

[1]Dry weight and volume basis.

Table 3.—EQUILIBRIUM SWELLING OF UNIMPREGNATED AND METAL-IMPREGNATED DOUGLAS-FIR CUT IN EACH OF THE THREE STRUCTURAL DIRECTIONS

Type of specimen[1]	Swelling: Tangential Percent	Radial Percent	Volumetric[2] Percent	Ratio tangential to radial swelling
Unimpregnated:				
Cross section	7.12	5.00	12.12	1.42
Edge-grain specimen	7.57	4.48	12.05	1.69
Flat-grain specimen	6.39	5.74	12.13	1.11
Metal impregnated:				
Cross section	7.25	4.40	11.65	1.65
Edge-grain specimen	8.12	3.50	11.62	2.32
Flat-grain specimen	5.00	6.85	11.85	.73

[1]Specimens 1 inch by 2 inches by 2 inches.
[2]Sum of tangential and radial swelling.

Table 4.—TRANSVERSE BOUND-WATER DIFFUSION COEFFICIENTS FOR DIFFERENT SPECIES AND METHODS OF DETERMINATION

Species[1]	Specific gravity[2]	Diffusion coefficients in Tangential direction: From water absorption 10^{-8} cm.^{2} per sec.	Tangential direction: From swelling 10^{-8} cm.^{2} per sec.	Tangential direction: From electrical measurements[3] 10^{-8} cm.^{2} per sec.	Radial direction: From water absorption 10^{-8} cm.^{2} per sec.	Radial direction: From swelling 10^{-8} cm.^{2} per sec.	Radial direction: From electrical measurements[3] 10^{-8} cm.^{2} per sec.
Sitka spruce[4]	0.42	15 16 17	15 15 15				
Do	.38	19.6	17.3	12.8	19.7 19.2	21.2 19.5	21.2
Douglas-fir	.55	14.3 13.9	14.3 15.3	16.8 ----	16.7 16.4	16.3 16.4	16.0
Southern pine	.53	15.9 15.0	14.4 11.5	12.0 ----	16.7 17.8	19.9 18.4	14.4
Paper birch	.63	13.3 13.5	11.9 11.3	12.4 ----	14.4 13.6	12.8 12.8	14.2
Sweetgum	.57	12.4 11.7	12.4 12.4	12.0 ----	18.4 17.7	17.8 18.3	14.2 ---
Black cottonwood	.29		12.9 12.1	12.4 ---	---- ----	16.5 16.7	16.1
Average		14.7	13.6	13.1	17.1	17.2	16.1

[1] Except as noted, specimens were about ½ inch by 2 inches by 2 inches.
[2] Dry weight and volume basis.
[3] Using 40 x 10^{-8} cm.^{2} per sec. for the average bound-water diffusion coefficient in the fiber direction for the softwoods and 46 x 10^{-8} cm.^{2} per sec. for the hardwoods.
[4] One-sixteenth-inch edge-grain veneer.

the dimensions measured. Four specimens from a single species (two edge-grain and two flat-grain) were impregnated with molten metal at a time. The procedure used was virtually that previously described (12). In order to obtain the maximum possible penetration with molten metal, a more effective vacuum pump was used that reduced the pressure to less than 0.02 of a millimeter of mercury rather than 1 millimeter of mercury as before. A higher pressure of 2,800 to 3,000 pounds per square inch was also applied. The calculated extent of filling relative to the theoretical maximum varied from a low value of 0.77 for sweetgum to a high value of 0.92 for the sapwood of southern pine. This is virtually the same range of filling found for cross sections (12). The extent of penetration was adequate in all cases for obtaining an initial water adsorption that was proportional to the square root of time over sufficient distance to measure its slope, except for cottonwood. In this case measurements could only be made from the swelling data.

All specimens were edge-coated with two coats of aluminum paint to minimize edge diffusion.

Measurements were made of the rate of adsorption and swelling by the metal-impregnated specimens when they were immersed in liquid water at 25.3° C. Figures 3 and 4 give the results of the measurements for edge-grain and flat-grain specimens of Douglas-fir. In both cases the initial weight increase versus square root of time is linear, as was the case for metal-impregnated cross sections (12). The swelling in the direction of diffusion (tangential for Figure 3 and radial for Figure 4) is linear from the start, whereas the swelling at right angles to the direction of diffusion (radial for Figure 3 and tangential for Figure 4) is greatly retarded. This is in contrast to a slight initial retardation of both tangential and radial swelling for the cross sections (12). The immediately linear relationship in the diffusion direction would be expected, as swelling in this direction of diffusion can occur a lamina of thickness at a time without part of the lamina imposing restraints upon the others. On the other hand, swelling in a direction at right angles to the direction of diffusion should be significantly restrained, as the swelling of succeeding laminae in the thickness direction are restrained by the laminae that have not as yet swollen. These restraints are not rapidly relieved as they are for the cross sections. In the case of the cross sections, swelling is practically what would be expected for stress-free conditions by the time two-thirds of the final swelling has occurred. In the case of the radial swelling shown in Figure 3, it takes 4.2 times as long to attain two-thirds of the final radial swelling due to restraints as it does to attain two-thirds of the final tangential swelling, which in this case has been unrestrained.

If swelling in the radial direction could occur without restraint up to the same final value that it does under restraint, its rate would be increased as represented by the lower dashed curve of Figure 3. The plot was drawn to make it linear up to two-thirds of the final swelling in the same time that two-thirds of the final stress-free tangential swelling is obtained. This curve would give the same diffusion coefficient as the unrestrained tangential swelling.

Barkas (1) has shown that the equilibrium moisture content of wood can be affected to a marked extent by restraints. In the case of the metal-filled wood where restrains cannot be relieved internally, the water adsorption should be directly proportional to the volumetric swelling. It is thus possible to correct the moisture content values to stress-free conditions by multiplying the observed moisture content values by the ratio of the unrestrained to the restrained volumetric swelling. Within the accuracy needed for this correction, the volumetric swelling is equal to the sum of the tangential and radial swelling. For example, in Figure 3 after 900 minutes (30^2) the measured water adsorption is 15.1 percent, the unrestrained tangential swelling is 5.4 percent, the measured radial swelling is 0.4 percent, and the theoretical stress-free radial swelling is 2.3. The unrestrained moisture adsorption is then 20.1 percent ($15.1\left(\frac{5.4 + 2.3}{5.4 + 0.4}\right)$).

The upper dashed line of Figure 3 is drawn through a series of similarly calculated points. It represents the water adsorption that would have been expected if restraints to swelling and water adsorption had been absent. This plot is virtually linear up to 20 percent moisture content, which is two-thirds of the adsorption at the fiber saturation point. The time to attain this point of inflection is 900 minutes, the same as the time to attain two-thirds of the final stress-free tangential swelling. The experimental stress-free tangential swelling and the water adsorption corrected to stress-free conditions both give a diffusion coefficient D at an average moisture content of 20 percent of 14.3 × 10^{-8} cm.^{2} per sec. using the Boltzman form of Fick's general diffusion equation (7).

$$D = \frac{\pi v^2 E_a^2}{16 t} \qquad (1)$$

where a is the thickness of the specimen in the diffusion direction and E_a is the fraction of the final water adsorption or swelling attained at time t (when $E_a = 0.667$ and $t = 300 \times 60$ seconds for this particular example).

In a similar way the radial bound-water diffusion coefficients were found to be 16.7×10^{-5} cm.^{2} per sec. from the corrected water adsorption data and 16.3×10^{-5} cm.^{2} per sec. from the stress-free radial swelling in Figure 4.

Table 3 gives the equilibrium tangential, radial, and volumetric swelling and the ratio of tangential to radial swelling for thin cross sections, edge- and flat-grain specimens of Douglas-fir both unimpregnated and impregnated with molten metal. The volumetric swelling (tangential plus radial) is virtually the same for the unimpregnated specimens cut in each of the three structural directions, which are only slightly more than the respective metal-filled specimens. In both cases the stress-free tangential swelling of the edge-grain specimens is greater than that for the cross sections, and the restrained radial swelling is less than for the cross sections. Conversely, in the case of the flat-grain specimens the unrestrained radial swelling is greater than that for the cross sections and the restrained tangential swelling is less. These effects are more pronounced in the case of the metal-impregnated wood than for the unimpregnated wood due to the fact that restraints cannot be relieved internally in the former case.

The effect of stresses reducing the swelling at right angles to the direction of primary diffusion (widthwise of a board) and not reducing the swelling in the direction of primary diffusion (thicknesswise of a board) has been observed by Perkitny (6) and by Vorreiter (14). The former has shown that for specimens of pine with a thickness of 5 millimeters in the tangential direction and 75 millimeters wide in the radial direction the ratio of tangential to radial swelling was 2.46, and when the dimensions were reversed the ratio was 1.51. The latter ratio is practically the same as that in Table 3. The change in Perkitny's ratio was 63 percent. The change in the ratio for the nonimpregnated wood of Table 3 was 52 percent.

The ratio of tangential to radial swelling also changes greatly during the course of swelling. When the free tangential swelling of Figure 3 is 2.70 percent, that is, one-third of the equilibrium value, the radial swelling is only 0.1 percent. The ratio of tangential to radial swelling in this case is 27.0. When the free radial swelling of Figure 4 is 2.28 percent, that is, one-third of the equilibrium value, the tangential swelling is only 0.4 percent. The ratio in this case is 0.175. Thus, before restraints are appreciably relieved, the effects shown in Table 3 are far more pronounced.

Table 4 gives the transverse bound-water diffusion coefficients for six species of wood, calculated from the rates of water adsorption corrected to stress-free conditions and from the rate of swelling in the stress-free diffusion direction, together with the values calculated from the ratios of transverse to longitudinal electrical conductivity and the bound-water diffusion coefficient in the fiber direction. The agreement between the values calculated in three ways is reasonably good considering the complications of the measurements and the magnitude of the corrections.

Conclusions

The analogy between electrical conduction and diffusion that was previously shown to hold through the solution-filled capillary structure of wood (2) also holds for conduction through and diffusion of bound water below the fiber-saturation point.

The specific electrical conductivity of wood in the radial and tangential directions ranges from about 1/3 to 1/2 of that in the fiber direction, with the radial conduction tending to be 17 to 25 percent greater than the tangential. This is probably due to the rays contributing to conduction in the radial direction like tracheids in the fiber direction and due to the better alinement of tracheid walls in the radial than in the tangential direction.

Swelling occurs without restraint in the direction of diffusion but under restraint at right angles to diffusion. The effect is more pronounced in metal-impregnated wood than in normal wood. Before equilibrium conditions are attained, the effects of restraint to swelling at right angles to the direction of diffusion are extremely high. Ratios of tangential to radial swelling may be as great as 27.0 when the restraint is radial and as low as 0.175 when the restraint is tangential for metal-filled wood in which restraints cannot be relieved internally.

The restraints at right angles to the direction of diffusion for metal-impregnated edge- and flat-grain specimens are sufficiently great to reduce the amount of water adsorbed. When the water adsorption is corrected to stress-free conditions by multiplying the actual water adsorption by the ratio of the stress-free volumetric swelling to the swelling under stress, the calculated bound-water diffusion coefficients agree with those calculated from the stress-free swelling in the fiber direction. The values also agree with those calculated from the bound-water diffusion coefficients in the fiber direction and the rate of transverse to longitudinal conductivities.

The bound-water diffusion coefficients are now known with sufficient accuracy to be combined with water vapor diffusion coefficients in calculating the combined diffusion coefficients in normal wood. This will be done in the next paper in this series.

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New Structures with Plywood...

SPACE PLANES, FOLDED PLATES, GEODESIC DOMES[1]

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Sound engineering research on diaphragm action of roofs and walls has resulted in folded plates, space planes, and other new structural applications of plywood that enable the architect to create modern, efficient, imaginative structures with wood. Availability of these and other units in component forms will open new markets to plywood in construction

SPACE-PLANE CONSTRUCTION—The last of 80 stressed-skin panels, made in 4 triangular shapes and sizes, goes into place in a St. Louis church. Panels interact as do folded plates in simpler structure, and no other supports are required for the shell, which has a clear span of about 100 by 32 feet and a height of 35 feet.

ONE CAN HARDLY EXAMINE THE PRODUCTION figures of the fir plywood industry without being struck by the amazing way in which it continues to grow. The production in 1959 from 145 fir plywood mills in the Western United States was 7.7 billion square feet, on a 3/8-inch basis. The production for 1960 has been estimated at 8.3 billion square feet, which compares with a production of 2.5 billion square feet in 1950, and only 1.2 billion square feet in 1940. Even so, the per capita consumption in the United States last year was only 42.4 square feet, while that in Canada was substantially higher.

It has been estimated that about three-fourths of the fir plywood production goes into construction. For this reason, the industry not only develops its traditional construction markets, such as sheathing, underlayment and concrete forms, but also concentrates on finding new uses for plywood within the construction field. Structural research is particularly important because rapid changes in the technology of the construction industry can make entire areas of use obsolete very rapidly.

The plywood industry publicizes new and original uses developed by its own research efforts, as well as those developed independently by architects and engineers, with the thought that when other designers see what can be done successfully with fir plywood, they are encouraged to use it in their own designs. For this reason basic data on plywood's fundamental physical and mechanical properties are made available to designers.

In addition to its research efforts, the industry's trade association, the Douglas Fir Plywood Association, maintains a design and engineering service. This service will provide upon request suggested designs for specific cases, or will check designs submitted by architects with respect to proper plywood use. At present, some two thousand inquiries are handled annually by this service, many of them requiring a substantial degree of mathematical analysis.

An Engineering Material

These activities rely on one basic assumption; namely, that fir plywood is an engineering material. This is to say that its performance under given circumstances is predictable with sufficient accuracy to warrant confidence in its use. There are two things necessary for this assumption to hold true. First, plywood must be manufactured to a standard, and second, the minimum properties of that standard panel must be known.

For Douglas fir plywood, the standard is U. S. Commercial Standard CS45–60, while for other Western softwood species it is U. S. Commercial Standard CS122 60. Both of these standards specify the minimum grades of veneer and the various species combinations that may be used, as well as minimum performance requirements for the glue bond. Mills that are members of the Douglas Fir Plywood Association and who are subject to its rigorous quality control program, have the advantage of having these requirements checked by an independent testing agency whose requirements exceed those of the Commercial Standards. Panels that conform with the DFPA requirements may be identified as produced under this quality control system with the DFPA grade-trademark. Architects are

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[1] Presented at Session XIX, Veneers and Plywood, FPRS 14th National Meeting, June 9, 1960 in Montreal, Canada; approved for publication August 8, 1960.

FOLDED-PLATE CONSTRUCTION—Stressed-skin plywood panels, connected along one chord to form a giant V-shaped room component, go into place in Seattle school. Folded plate in the background spans 70 feet and is believed to be the longest clear-span folded-plate in the nation.

encouraged to specify such grade-trademarked plywood so as to be sure that it actually will perform as assumed in their designs.

Supervision of plywood quality at the time of manufacture is vital for two reasons. First, the glue bond integrity is absolutely essential to proper performance under all conditions; second, the grade and species of the inner plies is often as important as that of the faces from an engineering viewpoint. Since neither of these factors can be determined by visual inspection upon delivery of the material to the job, it is desirable, and in many cases, mandatory under the building codes, to have an independent agency other than the producer vouch for conformance of the panel with the appropriate standard.

Because plywood is used in engineering design its strength properties are of paramount importance, and they must be absolutely reliable. Plywood working stresses are derived from the known strength properties of wood by a rational analysis, with due regard to veneer construction and the direction of the acting stresses. As with other materials, a system of working stresses is employed so that in normal applications plywood will be stressed well below its ultimate strength. These working stresses are derived from the so-called "basic stresses", which are listed in the U. S. Forest Products Laboratory's Wood Handbook for various species.

Sheathing Applications

The most spectacular growth in plywood applications in the past decade has been in the area of sheathing uses. Two factors have contributed notably to this development. One is the fact that lower grades of logs are being used more commonly, so that there are available greater proportions of the C and D grades of veneer that are used in making the sheathing panels. The second factor is that builders in general discover that the labor savings made possible by the use of plywood result in lower costs in place. This savings becomes more and more signficant as site labor costs continue their apparently endless upward climb.

Plywood sheathing is used commonly for walls and subfloors where its racking strength, nailing properties and dimensional stability make it a preferred material. Probably the largest single use, however, is as roof sheathing.

With the advent of plywood's common use as sheathing, the question arose as to its ability to brace a building through structural diaphragm action. Its considerable racking resistance had been well known for years, but now the emphasis fell on being able to calculate it numerically—in other words, to actually design with it. This was particularly pronounced in the California area where buildings are commonly designed for resistance to lateral seismic forces and use of the sheathing as a structural diaphragm makes it possible to eliminate costly diagonal bracing members.

Beginning in 1949, the DFPA undertook to investigate the design of plywood diaphragms based on analysis and full-scale tests. As a result, a design method and recommended shear values were derived. These were reviewed and adapted by the major regional building codes in the United States and have gone far in helping to establish a major market for plywood sheathing applications.

Folded Plates

One of the unexpected benefits of the diaphragm research was that it paved the way for the development of folded-plate construction. A folded plate is a form of thin shell construction consisting of inclined planes having a common framing member at their intersection. These framing members, or chords, carry direct stresses, while the plywood web carries shear. They may be considered somewhat as beams, tilted on their sides, usually forming a sawtooth pattern in cross section. They span in a direction parallel with the ridges and, much like corrugated metal, depend on their shape to achieve good load-carrying capacity for a given amount of material.

Each individual plate acts as a diaphragm and can be analyzed as such. The chords are generally glulam members carrying compression or tension so that any end joints must be spliced. Steel tie rods or other methods are used to carry the horizontal thrust developed over the bearings. The plywood webs of the diaphragms are supported by wood framing running between chords, the web thickness being generally determined by shear requirements. This shear also fixes the nailing schedule, which is usually much heavier than that ordinarily used for sheathing.

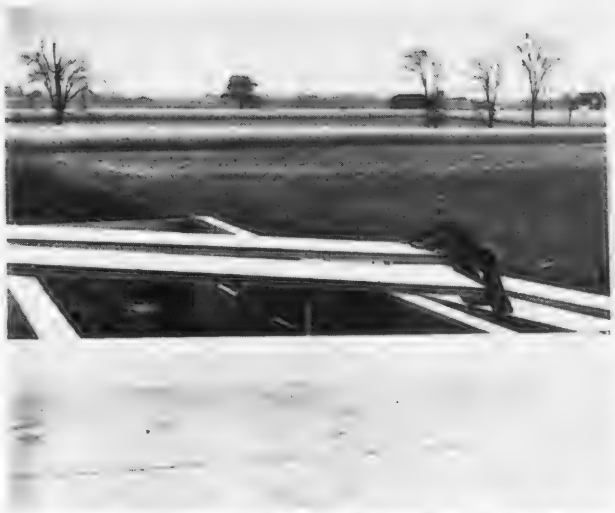
Although deflection of the folded plates can be calculated when only nails are used, sometimes glue is also employed in attaching the plywood so as to stiffen the assembly. However, its strength is not always counted on if site-gluing is used. Camber may be introduced to offset dead load deflection and to facilitate drainage.

Folded plates are generally site-built, much like conventional frame construction. However, panels are often prefabricated (sometimes using glued, stressed-skin panels), shipped to the site flat, assembled into Vees, and erected. Designs have been made for spans ranging up to 120 feet, although the more common spans used are generally about 40 feet, plus overhangs. A design method has also been developed for cross sections that are trapezoidal rather than triangular.

Space Planes

Experience with the folded-plate design method, showed that other shapes even more exciting to architects could also be analyzed with it. These shapes are numerous, but have in common the fact that their cross section varies along the span. They consist generally of folded plates having non-parallel chords, and have been called "space planes."

PLYWOOD BOX BEAMS—These 60-foot beams are 6-⅞ inches wide and 30 inches deep. They taper to 12 inches deep the last 8 feet of one end to form a canopy. Flanges are three 2 x 6s on edge; webs are ⅝-inch A–C exterior where exposed and A–D elsewhere.



STRESSED-SKIN PANELS—These roof panels are 20 feet long and 4 feet wide. They have a ⅜-inch plywood top skin and a 5/16-inch bottom skin and are framed with glue-nailed 2 x 4s.

One of the simplest examples of a space plane is a dome-shaped structure, polygonal in plan, in which chords radiate from a central point, alternately forming ridges and valleys to give a pleated effect. The triangular spaces in between are sheathed with plywood to carry the shear and form a folded plate.

Analysis of such sections is somewhat complicated, but it has been reduced to general equations for thrusts and shears for a polygon of n sides under uniform vertical loading, based on certain assumed conditions. Such pleated roofs have been designed in diameters ranging up to 200 feet.

Other more complicated spaceplanes structures have been built. There is not yet any general design method, as each proposed structure is usually different, depending on the shape that appeals to the designer's imagination. Usually, they consist of large intersecting triangular planes that may be prefabricated and hoisted into place. Previously, such structures have been normally done in concrete, but with the availability of adequate plywood design data, the same forms can be obtained with the additional economy of wood construction. This provides the architectural profession an additional medium, at the same time illustrating the innate versatility of wood.

The space-plane development is a far cry from the original objective of the research on diaphragms, yet there is no sign that the end of this progression is yet in view. The original research, started a decade ago, is continuing to pay dividends in the form of increased markets for plywood. It is anticipated that other forms of research currently underway on such shapes as geodesic domes, hyperbolic paraboloids, and other thin-shell structures may have similar successful results.

Components

In recent years it became evident that new concepts in plywood application were being developed through structural research that could not always be used immediately by the building industry. These forms generally required gluing for maximum efficiency, which ordinarily cannot be done reliably in the field with present techniques. Also the increase in site-labor costs has led builders to seek new methods to replace the costly conventional methods of hand assembly of a great number of pieces.

Both of these factors argued for the development of a prefabricated component industry, that could furnish to builders more or less standardized pieces from which the structural parts of a building could be assembled rapidly. Such components differ from the usual prefabricated section in that, ideally, they may be used in putting together almost any building, whereas a prefabricated section is intended for a specific model of a particular system, usually residential.

Typical components are usually framing members, such as a truss or a plywood beam or panels, such as a wall, floor or roof member. Indeed, a piece of dimension lumber or a plywood panel might be considered as a component. In the usual understanding of the word, however, a more sophisticated unit is implied—generally one that performs a specific structural assignment, and preferably other functions as well, such as thermal insulation, weather-proofing, and finishing.

Because these members may be used in any type of construction, it is necessary to develop reliable engineering data on their capacities. Since the material used in shop-built members can be closely controlled with regard to grade and moisture content, higher working stresses may often be used, provided the pieces are properly regraded and the refinements called for in the design are actually provided. Thus, greater structural efficiency of material is attainable in shop-built members than in conventional site-built members, with correspondingly better utilization of wood.

New Industry Established

A year ago there were few, if any, fabricators in business who had the necessary background to engage in manufacture of plywood components. Also missing was an ingredient essential to the successful marketing of a structural member—namely, an acceptable standardized product produced under a reliable form of independent quality supervision. There was a strong feeling that a fledgling industry could ill afford a structural failure due to inadequate fabrication, particularly where life hazard was involved. This feeling was echoed vigorously by building officials, who are often in a position to accept or prohibit a particular method of construction in a large market area if they are not satisfied that it is safe.

With all of these considerations in mind, the DFPA established on a pilot plant basis, in March 1959, an organization known as Plywood Fabricator Service, Inc., or PFS. The purpose of PFS was to foster a plywood component fabricators' industry, and

OPEN-FACE PANELS—These stressed-skin panels, which were used over 24-foot spans, were fabricated with one face to facilitate plumbing and wiring, and the second skin was added later.

to provide an effective system of inspection and quality control.

The PFS organization is an affiliate of the DFPA, and is supported by the latter in its advertising and promotional program. The 80-man DFPA field force promotes components directly to architects, thus supplying sales leads to PFS members. Design and fabrication specifications are developed by the Technical Department, and it is these specifications that are enforced by the PFS quality control system. New components are investigated and developed by research facilities of the DFPA, while engineering advice to architects on specific applications is made available through their design service.

The PFS staff maintains quality supervisors and laboratory testing facilities in each region where it operates. It also maintains a staff of engineers to assist its members in design, and to help in plant layout and development of production equipment. Its operation is in the process of being expanded nationwide, after an initial nine months trial in the two original pilot areas.

Quality Control

Plywood components produced by PFS members are subject to a quality control system patterned after that of the DFPA. This includes requirements for initial qualification in any one of several classes of production, depending on the type of component and the adhesives, whether interior or exterior. The plant, equipment and operating personnel must be adequate to the satisfaction of a PFS examiner. A series of glue-bond specimens made in actual production runs must pass specified tests before initial qualification is extended.

Once qualified, the plant is subject to continuous inspection for conformance with applicable specifications. Such inspection covers grading and laminating of lumber where necessary, surfacing, moisture content, assembly, glues and gluing processes, finishing and sampling.

Test samples themselves are taken from specified locations of actual members with a core saw of sufficient diameter so that a specimen having a 1- by 1-inch glue joint test area can be obtained. In general, 5 percent of the members produced are sampled, but a certain minimum weekly quota is set. There is provision for increasing the sampling quota at any time conditions warrant it.

The core sample is sent to the nearest laboratory where a step-type block shear specimen is cut from it and subjected to the appropriate durability test. Interior type bonds are soaked in water at room temperature for 4 hours and dried to a maximum moisture content of 8 percent for 19 hours, with the process repeated through 3 cycles. Specimens are then examined for delamination with a high percentage of specimens required to pass both the first and third cycles.

QUALITY CONTROL—Core panels taken from 60-foot plywood box beam will be subjected to glue-bond tests.

Exterior type specimens are subjected to a soak in water at room temperature for 48 hours, then dried for 8 hours at 145° F., followed by 2 cycles of soaking for 16 hours and drying for 8 hours. After a final 16-hour soak the specimens are broken and the percentage of wood failure estimated, with high average and minimum wood failure required to pass. Both interior and exterior durability test requirements are set so as to correspond with those required of fir plywood in the Commercial Standards.

Dry shear tests are also run on both types of specimens with average and minimum stress and wood failure requirements specified.

Critical members (those beams and panels that exceed certain span or loading conditions) may be grade-trademarked only after receipt of satisfactory test reports from the laboratory on specimens from each lot produced. Other standard production may be grade-trademarked when the fabricator is qualified in that classification, providing that he is maintaining a satisfactory test record.

There are provisions for inspection of grade of all members produced and provision for withdrawal of grade-trademarking privileges when the fabricator fails to meet the grade or the glue bond performance requirements.

Conventional components may carry the PFS grade-trademark only when they comply with the appropriate DFPA fabrication specifications, which are as follows:

DFPA Specification No. BB–8—Fabrication of Plywood Beams

DFPA Specification No. SS–8—Fabrication of Flat Plywood Stressed Skin Panels

DFPA Specification No. CP–8—Fabrication of Curved Plywood Panels

DFPA Specification No. GT–8—Fabrication of Trussed Rafters With Plywood Gusset Plates

DFPA Specification No. TD–60—Fabrication of Trofdek Units

In addition to the Fabrication Specifications, there are Design Specifications recommended for use by the designer. These include a General Design Specification for Glued Plywood Lumber Structural Assemblies, as well as one for box beams and curved panels, and one in process for stressed-skin panels.

Plywood box beams are hollow, light-weight structural members having vertical webs of plywood to carry the shear, while bending stresses are carried with glulam lumber flanges. Although they have been made in spans of 80 and 90 feet, it is more common to see 40 and 50-foot spans. The maximum depth is generally 48 inches but depth and other dimensions are determined by load-span requirements. Generally, box beams are rectangular, but their cross section may vary either in depth or otherwise along their length.

Stressed-skin panels are hollow assemblies utilizing lumber framing with plywood skins glued to one or both sides. They may be used in spans ranging from 8 to 24 feet, with 10 feet being a common size. Plywood skins are either scarfed, or butted and spliced with a plywood gusset. Panels may include insulation, and provision for ventilation is generally desirable in order to avoid condensation.

Such panels are normally made flat but they may be curved to achieve an architectural effect. If thick enough

they may function as curved beams, or, providing tie rods are supplied, as a tied, two-hinged arch.

Light residential roof trusses may also be made using glued plywood gusset plates and lumber framing. Such trusses can be exceedingly strong and stiff, and have been used in large quantities (set 16 inches or 24 inches on center) to obtain a clear-span area.

Other types of plywood components are in the offing. These include Trofdek, a series of light weight folded plates utilizing 5/16-inch plywood webs with light flanges on top and bottom made from 2-inch lumber, and scarf jointed to full length. Such members may have depths ranging up to 17 inches and are capable of spanning up to 40 feet or even more, depending on the roof load. They may also be used for floor sections on shorter spans.

Another type of plywood component at present under development is the panel section for a geodesic dome design. Such sections will consist of stressed-skin panels warped into the shape of a hyperbolic paraboloid approximately 8 feet square. When assembled into the dome, they will form a shell structure that should be satisfactory for domes ranging up to at least 60 feet in diameter.

These and other units are now being or soon will be manufactured by members of Plywood Fabricator Service. They all represent a construction item of known standards that will be made under a rigid quality-inspection system. It is anticipated that they will be effective in providing a new market for glued plywood and lumber products by making available to the nation's architects a product of reliable quality, tailored to their requirements.

Relation of the National Wood Promotion Program to Educational Training Programs[1]

ENVIRONMENT FOR LEARNING is an informative new booklet directed toward school officials and planners, members of school boards, Parent–Teacher Associations and similar lay audiences. It contains detailed information on maintenance, fire safety, economy, and structural integrity, and emphasizes the "welcome warmth of wood."

NLMA SCHOOL EXHIBIT at the Association of U.S. and Canadian School Business Officials Convention, Oct. 11–15, 1959, in Miami, was visited by 1700 people. Shown are R. F. Goodney, NLMA Regional Manager of Technical Promotion, Dallas; and J. E. Crews, Business Manager of Waco, Texas, school system.

PAUL R. BEATTIE

Manager, Technical Promotion Department
National Lumber Manufacturers Association

THROUGH THE TECHNICAL SERVices division of the National Wood Promotion Program, educational activities are being conducted in two important areas:

1. Familiarizing the student architect and engineer with the use of lumber and wood products as structural and finish materials.

2. Encouraging capable high school students to seek technical careers in the lumber and wood products industries.

I. ARCHITECTS AND ENGINEER STUDENTS

Wood Design Data Kits

Most of the engineers and architects who have been graduating from our technical schools recently have a good knowledge of design with steel, masonry and aluminum but many of them know little about specifying wood to its best advantage in building construction. Very definite efforts are being made to correct this situation. Good wood design literature has been supplied through the National Wood Promotion Program to the libraries of all recognized engineering, architecture, and wood science and technology schools. (This totals more than 300 schools in the United States and Canada.)

Some of the publications included in the library kits are Wood Handbook, Timber Design and Construction Handbook, Wood Structural Design Data, Douglas Fir Use Book, Modern Timber Engineering and National Design Specification for Stress-Grade Lumber and Its Fastenings.

National Design Specification

In addition to the library kits individual copies of "National Design Specification" are being made available to seniors and other students at the schools who have need of them. During the last 6 months approximately 1,000 copies were supplied to 30 institutions of higher learning for redistribution to senior students. Some of the institutions were University of New Brunswick, Rutgers, University

[1] Part of a panel presented at Session XIV, Industry-Education, FPRS 14th Annual National Meeting, June 8, 1960 in Montreal. Revised copy received September 12, 1960.

ONE OF 4 SUCCESSFUL LUMBER SEMINARS was held at Colorado State University, April 5–8. Seated, l. to r.: C. A. Rasmussen, Western Pine Association; C. Boardman, Western Pine Association; J. I. Zerbe, Education Services Department, NLMA; H. Troxell, Professor of Wood Technology, CSU. Standing, l. to r.: R. G. Kimbell, Jr., West Coast Lumbermens Association; R. A. Glaze, RILCO; R. L. Fletcher, Timber Engineering Company; N. H. Reece, Technical Promotion, NLMA; A. M. Camarano, Government Specifications Department, NLMA.

WOOD FOR RAILROAD USES was discussed in a symposium held in Chicago, June 2, to create a wider acceptance and appreciation of wood. L. to r.: R. D. Behm, representing Hardwood Plywood Institute, American Walnut Manufacturers Association, and Fine Hardwoods Association; A. E. Lawler, Wood Grain Door Committee, NLMA; H. B. McKean, Potlatch Forests, Inc.; N. B. Garlock, National Paint, Varnish and Lacquer Association; A. M. Camarano, Government Specifications Department, NLMA; P. R. Beattie, Technical Promotion Department, NLMA.

of Maine, University of British Columbia, University of Connecticut, Colorado State University, Louisiana State University, University of Florida, Wright–Patterson Air Force Base and Michigan State University.

During the succeeding six months additional copies of NDS will be supplied to a more nearly complete coverage of seniors who will be graduating from schools of architecture, engineering and wood science and technology. Packages of wood design books are also to be supplied to the heads of departments at the schools.

Seminars and Lectures

Four successful one-day lumber training seminars were held for civil engineering, architectural and wood science and technology students during April. Contacts were made with about 500 students, professors and practitioners at presentations to groups at the Univerity of Denver, University of Colorado, Colorado State University and the University of Wyoming. Faculty members at these schools expressed pleasure at the information on growth properties of wood, grading, wood engineering, glue-lam construction, fastenings, specifications and building codes as it was presented by NLMA in cooperation with regional associations and the American Institute of Timber Construction.

Because of the success of the programs as indicated by the manifestations of interest and invitations for reappearances in the future it is planned to participate in as many similar functions throughout the country as is possible. This activity appears to be a good means for accomplishing a broader education program on wood

The focal point for the educational activities in the National Wood Promotion Program are the student architect and engineer, and the capable and interested high school student.

for architects and engineers in accordance with the objectives of an expanded technical promotion program. Plans are presently being made for a similar seminar to be held at the University of Minnesota this fall.

During the past year, several members of the technical services division have presented lectures at University of North Dakota, Iowa State, University of Michigan, Michigan State, University of Cincinnati, Penn State, Lehigh, Drexel, and others. The talks usually incorporate the use of 35 millimeter color slides, 16 millimeter film and/or samples of lumber and wood products. A question and answer period is usually held at the end of the presentation and literature by NLMA, its members and other cooperating organizations distributed to the students.

Visual Slide Library

A file of colored slides for use by the NLMA staff and industry representatives in lecturing to students, service clubs, classes and meetings of all kinds has been established. At present the file contains 2 inch by 2 inch slides of residential construction, churches, schools and commercial buildings. As the file is built up, it will eventually contain slides on wood properties, special methods of construction, staff activities, finishes, fastening, secondary uses of wood and logging and manufacturing operations as well. A catalogue of the slides in the file will be completed in the near future and will be maintained at all the NLMA field offices as well as the Washington headquarters office.

II. HIGH SCHOOL STUDENTS

Cooperation of NLMA and FPRS

The cooperative program between the National Lumber Manufacturers Association and the Forest Products Research Society to increase enrollments in collegiate wood technology, wood utilization and forest products engineering curricula is now 2-½ years old. In line with original program objectives 2 publications have been prepared and are now being distributed. Approximately 15,000 copies of the career booklet "Opportunities Unlimited for Careers of Prestige and Profit in the Forest Products Industries" have been distributed throughout the United States.

Write-in requests for single copies of the booklet have increased mainly because of publicity accorded through distribution of the companion flier, "There Is a Challenging Place for You in A New Age of Wood." This pamphlet which contains a coupon that may be used to request free copies of "Opportunities Unlimited" has been sent to high schools, principally through cooperating wood science and technology schools.

Recently we have been receiving requests for "Opportunities Unlimited" as a result of an article on it which was carried by the March 1960 issue of HIGHLIGHTS, a publication of the Bureau of Guidance of the New York State Education Department. Other State Education Departments are also assisting in the distribution of educational publications. The career booklet is also included in the Career Day packet distributed by the American Forest Products Industries, Inc.

With the increasing need for technical promotion, sales engineering, product development and research men in the industry, the recruitment of more wood science and technology students through wise use of the NLMA career publications can be of much assistance in advancing our product technology and keeping wood in effective competition with other building materials as steel, plastics, masonry and aluminum.

Assembly Lectures

Occasionally, members of the Technical Promotion field staff get the opportunity to make presentations before high school assemblies. Recently our New York regional manager of technical promotion, Carl Darrow, talked to approximately 750 high school students in Baldwinsville, Gardner and Winchendon, Mass. The groups consisted of students interested in forestry, science classes and boys in grade 7 through 12. Mr. Darrow made a brief talk on "Opportunities in the Forest Products Industries," showed the New York State College of Forestry film, "New Horizons for Wood," and distributed copies of "Opportunities Unlimited" and the leaflet "New Age of Wood." These meetings were made possible by Mr. Frank Potter, Secretary–Manager of the Greater Gardner Chamber of Commerce and Dr. Gatslick of University of Massachusetts.

Career Day Programs

Copies of "Opportunities Unlimited" are continuously being made available to personnel in the lumber and wood products industries for Career Day talks at high schools and colleges. Dr. Richard Jorgensen of the Pennsylvania State University recently informed us that he makes about 2 high school career day talks a month and utilizes copies of the "Opportunities Unlimited" booklet.

During the engineering school open house program at the University of Michigan last May, our Chicago regional manager of technical promotion, Henry Voorhees, attended the NLMA exhibit and talked to approximately 100 high school students about the opportunities in the forest products industries. Approximately 500 high school students from all over the state of Michigan attended the open house program sponsored by the University of Michigan.

Cooperation with Extension Foresters and County Agents

The State Forestry Extension Services have been helpful in disseminating information on opportunities in the forest products industries to interested high school students and others. Our Cleveland regional manager of technical promotion, William Penoyar, has personally worked with Norm Higgins, Extension Specialist in Forest Products for Michigan State University, and the author has personally cooperated with Carl J. Holcomb, Extension Forester for the Virginia Polytechnic Institute. Both of these gentlemen have kindly distributed our publications and other information to the district foresters and county agents in their respective states.

Enlisting the aid of the four to five thousand county agents and district foresters in the United States to stimulate high school students to enter the field of forest products, will be a great aid to our cooperative educational training programs. We sincerely appreciate their assistance.

III. CONCLUSION

The National Wood Promotion Program is currently considering the expansion of activities and personnel. The expanded program will require additions to the following departments in the technical services division: building codes, engineering, fire insurance, technical writing and technical field promotion. Most representatives of our present technical promotion field staff have advanced degrees and experience in the fields of wood technology, wood utilization, construction and merchandising. We are grateful to the schools and industries that have trained these men and who are continuing to educate young men who may be additions to our program in the near future.

The continuation of our present cooperative efforts and the materialization of future ideas and plans will certainly aid our present educational training programs in supplying more and better trained men in fields of lumber and wood products.

there's nothing

in the world

like WOOD

FOR HOME EXTERIORS WITH LASTING GOOD LOOKS—This advertisement appeared in national magazines, promoting the use of wood siding over wood sheathing.

FOR WINDOWS THAT WED BEAUTY TO DUTY—This appealing picture was created to point up the insulating qualities of wood window frames.

COMMERCIAL STANDARDS FOR Hardwood Plywood Products[1]

WILLIAM J. GROAH
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Commercial Standard CS35, "Hardwood Plywood," is under revision and two new standards covering prefinished wall panels and laminated-block flooring are being developed. All three standards must consider 1) the basic material, 2) manufacturing techniques, and 3) consumer expectations.

IN THE DEVELOPMENT OF COMMERCIAL STANDARDS for wood and wood products—of which hardwood plywood is one—three important factors must be considered: 1. The character of the basic material—the tree. 2. The type of product that can be produced according to existing manufacturing procedures and techniques. 3. The type of product desired or expected by the consumer.

While there are other important elements that contribute to the development of a commercial standard, the three factors listed above are the primary considerations. It is admitted that each of these factors can be controlled or conditioned to a certain extent, a realistic standard can be developed only as long as each factor is kept in proper prospective.

In the past 2 or 3 years, there has been work underway on the revision of commercial standard "CS35–Hardwood Plywood," and two other standards, one for prefinished hardwood wall panels, and one for laminated hardwood block flooring are being developed.

Revision of CS35–56

The new edition of CS35 can be better described as an expanded standard rather than a revised standard. There have been revisions, but most of the important changes have been in the form of additions.

One of the more important changes in CS35 is the realinement of face designations. What has been done in the proposed standard is to expand the regular grades (those with a numerical designation) to include a premium grade for certain types of wall panels and flush door faces. The premium grade will be designated as No. 1, and the good grade will also carry No. 1. The quality of veneer making up premium grade will be essentially the same quality as that making up good grade; the chief difference being that premium veneers will have to be for grades designated as "good," "sound," "utility," and "backing," are unchanged in the new edition.

Custom grade is now called "speciality grade," and its position has been changed from the leading paragraph of regular grade listings to the final paragraph. This change in position, plus some change in wording, eliminates in the inference that this grade was some kind of a super grade. The custom grade has always been intended to be a catch-all for plywoods that did not fit appropriately in the regular grades. The new edition of the standard emphasizes this intent.

Another change in the proposed CS35–60 is an expansion of types of construction. Two new types of hardwood plywood construction have been recognized in the new edition—particle board core construction and softwood inner ply construction. For these types of construction, glue-bond test procedures have been handled by existing CS35 tests and by reference to present applicable standards or proposed tests. For example, references are made to standards CS45, CS122, CS157, and to ASTM test methods. A table requiring certain grades of softwood crossbands and inner plies under certain grades of hardwood plywood face veneers has also been added to the new edition.

There are other changes in this standard, but most are of a minor nature. Standard sizes and thicknesses of hardwood plywood have been altered to be more consistent with prevailing commercial practices. There has been some revision of the lumber core grades. Some species have been added, and some deleted from the standard.

Prefinished Wall Panel

About 3 years ago a project was initiated to develop performance standards for finishes applied to plywood wall panels. When the project was originated it was decided to divide the properties of finishes into 1.) physical properties, and 2.) chemical properties.

Investigations and tests have been made in relation to the following physical properties of finished plywood: 1.) film thickness, 2.) impact resistance, 3.) cold-check resistance, 4.) color retention, 5.) mar resistance, 6.) wear resistance, and 7.) scratch resistance.

The chemical properties considered were 1.) resistance to hot and cold water, 2.) resistance to smoke, and 3.) resistance to some 18 staining agents.

During the past three years many of the original test procedures have been discarded, many have been modified, and new procedures have been adopted. Many test procedures which were investigated were found to be not applicable, but the chief difficulty seemed to be with the varying types of finishes. On the one hand, there are those types of finishes that form a continuous film on the surface of the wood; on the other hand, there are finishes that penetrate into the wood and form a top surface that is a combination of finishing material and wood. It is difficult, if not impossible, to evaluate these two types

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[1] Presented at Session XIX, Veneer & Plywood, FPRS 14th Annual Meeting, June 9, 1960 in Montreal, Canada; approved for publication September 2, 1960.

Table 1.—PERCENTAGE OF BLOCKS THAT PASSED DELAMINATION TESTS (BASED ON 1690 BLOCKS).

Company								
A	B	C	D	E	F	G	H[1]	H[2]
Average Overall Percentages								
80.0	74.5	58.5	81.1	81.5	63.0	97.0	61.0	68.5

Block Size	Boil Test	Drying Condition
4"x8"—75.8% 6"x6"—71.0%	1-hour boil—83.4% 2-hour boil—63.5%	Room temp. drying—70.6% 145° F. drying—76.3%

H[1] and H[2] represent two different glue formulations used by Company H.

Table 2.—TOTAL NUMBER OF INCHES OF DELAMINATION IN VARIOUS BLOCKS.

Company								
A	B	C	D	E	F	G	H[1]	H[2]
Total inches of delamination								
162	310	450	142	49	736	14	457	848

Block Size	Boil Test	Drying Conditions
4"x8"—1568" 6"x6"—1600"	1-hour boil—999" 2-hour boil—2169"	Room temp. drying—1774" 145° F. drying—1394"

H[1] and H[2] represent two different glue formulations used by Company H. The total inches of delamination are taken only from 6 days of each company's test blocks to facilitate a direct comparison.

of finishes by one group of tests. It would seem that any commercial standard would either have to provide separate tests for the two types of finishes, or provide a weighted system of evaluation within the same group of tests.

There has been increasing interest recently in the development of a commercial standard for wall panels. Not only is there a need for finish standardization, but there is also a need for face-grade standardization. Commercial practices relative to faces for wall panels are inconsistent with the regular face grades for hardwood plywood. This is particularly true for the various V-groove styles. For example, the mismatched V-grooved panel, which simulates lumber planking, is quite inconsistent with the normal concept of grading.

Laminated-Block Flooring

The standard for laminated-block flooring should be available by the end of the year or early in 1961. This standard will cover one product—a 9- by 9-inch flooring block. Requirements generally will call for a three-ply block, ½ inch thick, made of oak, beech, birch, cherry, maple, hickory, pecan, or walnut.

The standard will provide for two face grades (Prime and Standard), inner ply requirements, one back grade, veneer thicknesses, dimensional tolerances, moisture content tolerances, and glue-bond tests.

Laminated-block flooring is installed in the interior of buildings, usually directly on concrete. Since the block is exposed to more strenuous conditions than most interior plywoods, it was felt that something better than a Type II (Interior) Bond was required. A modified Type II or a modified Type I Bond would probably be applicable.

To determine the quality level of laminated blocks and to develop a standard glue-bond test procedure for the modified Type I Bond, the following tests were made on the products of eight companies: Twenty test blocks per day were sent from each company. One company sent blocks in for 6 days, a second company for 8 days, and a third company for 20 days. During the first 10 days, the blocks from the third company were manufactured with one glue mix; the second 10 days, the blocks were manufactured with a second mix. The five other companies sent blocks over a 10-day period.

From the 20 blocks sent from each company each day, 5 were subjected to each of the following tests:

1. One-hour boil—20 hours of drying at room temperature.
2. One-hour boil—20 hours of drying at 145° F.
3. Two-hour boil—20 hours of drying at room temperature.
4. Two-hour boil—20 hours of drying at 145° F.

All blocks were checked for delamination at the end of each test. Delamination was established when separation between any two plies was greater than 2 inches in continuous length and over ⅛ inch in depth at any one point along this length, and the width of the separation was equal to, or more than three thousands of an inch, as determined by a feeler gauge.

The first day that blocks were submitted they were cut into 4- by 8-inch specimens; the grain of the face ply being in the direction of the 4-inch dimension. The second day the blocks were cut into 6- by 6-inch specimens; on successive days each of the two size specimens were cut on alternate days. All edges were trimmed before the blocks were subjected to any of the boil-dry conditions.

The results of these tests were reported to the manufacturers individually at the time of test in the form of percentages of blocks passing a specific test. The results of these tests are on a total of 1,690 blocks.

There was a wide range between the company averages. Considering all conditions and specimen sizes, the lowest average observed for a company was 58.5 percent; the highest average observed was 97.0 percent. The overall average for all conditions, specimen sizes, and companies was 73.5 percent.

Considering only the size of the blocks, the overall average for the 4- by 8-inch blocks was 75.8 percent, the overall average for the 6- by 6-inch blocks was 71.0 percent.

Considering only the drying temperatures (room temperature and 145° F.), the average for room temperature was 70.6 percent, and the average for 145° F. was 76.3 percent.

From a standpoint of the boil time, the average overall results were: 83.4 percent for the 1-hour boil test and 63.5 percent for the 2-hour boil test.

Conclusions

The following conclusions are based only on a superficial view of the data, rather than a detailed statistical analysis:

1. The duration of the boil seems to be the most important factor. (83.4 percent for the 1-hour boil, 63.5 per cent—2-hour boil).

2. The data seem to indicate that room temperature is more strenuous than the 145° F. temperature, (room temperature—70.6 percent; 145° F. —76.3 per cent). The difference in these two percentage values for the drying temperatures could be attributed to experimental error and the natural variation of the test. It can be concluded, however, that if drying temperature is significant it would be significant in favor of the room temperature being the more strenuous condition.

3. The data indicate that the 6- by 6-inch specimen results in a higher percentage of failure than does the 4- by 8-inch specimen.

In addition to these percentage results, the blocks total number of inches of delamination were also calculated. These delamination values seem to indicate the same thing as do the percentage values—the 2-hour boil condition, the room temperature condition, and the 6- by 6-inch block size were the more strenuous. Tables 1 and 2 give a composite of the percentage data and of the data on inches of delamination.

Facts About Building Codes

THAT EVERY SUPPLIER *SHOULD* KNOW[1]

We must look twice at building codes—once from the official's viewpoint and once from our own as suppliers. We can gain a more favorable position for wood by tailoring our product to fit the end use. But to do this, we must have a thorough knowledge of the codes and the code writers and enforcers must have an honest desire to encourage these improvements.

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ONE OFTEN HEARS THAT THE MARKETS FOR FOREST PRODUCTS ARE LIMITED by restrictions placed on the use of wood in building codes. The implication often goes farther—that the restrictions are unfair and discriminatory. In the view of the proponent of a new building product, the typical building official is inflexible and completely blind to the product's true characteristics.

This image is, by and large, a false one. Most code officials and code-producing groups are sincere, conscientious individuals, who are acutely aware of their responsibilities to the public they are charged to protect, but who try honestly to take a fair and impartial view of the many innovations they are called upon to judge.

There *are* restrictive limitations on wood in building codes. Some of them are justified, and some are not. Where they are justified, often the product can be so modified that the reason for the restriction ceases to exist, and the code limitation can be lifted. When restrictions are unjustified, education and demonstration of facts can provide relief from onerous requirements.

Building code limitations and customer acceptance are so closely bound together that it is often difficult to separate them. The requirement which is found desirable in a building code—to protect the public—is usually good for the customer. It is when the building code restriction is antiquated or based on prejudice, as sometimes happens, that difficulties ensue.

The salesman wages a constant battle. He must first convince the customer that his product is economical and practical. Then he must demonstrate to the building official that the product is sound, safe, and should be permitted. He cannot understand why the building official does not share his enthusiasm. No wonder his image of code officials is false.

To better understand the viewpoint of those who produce building codes and those who administer them, let us briefly study the nature of the organizations and individuals responsible.

Code Producers vs. Enforcers

Those who produce building codes do not enforce them, just as lawmakers do not double as policemen. Although officials charged with enforcing building codes are usually consulted in their preparation and revision, the two functions are discrete. We therefore consider code *producers* and code *enforcers*, or building officials, separately.

The groups who produce building codes have a moral and professional responsibility to assure public safety. They must take an objective attitude, regardless of personal enthusiasms. Their decisions must be based on facts; if facts are not available, they must be based on the most reliable and experienced opinions available. The statements made to them on behalf of a desired code change must be supported by the best possible evidence. Who would wish to make a hasty decision based on sketchy evidence if it might mean the difference between life and death?

The building official who must administer the code is faced with a similar set of responsibilities. Certainly his moral responsibilities are equally great, and often his professional responsibilities. But he has another—the legal responsibility of enforcing the building by laws in the area under his jurisdiction. Failure to discharge his obligations properly may result in his being held personally liable. No wonder he is conservative.

Most municipalities, townships counties, states and provinces, have enacted by-laws to control building. They control an estimated 70 to 80 percent of all building construction. An even greater proportion uses some building code at least as a basis for the plans. Obviously building codes are a very important factor in the sale of building products. Certain other regulations, such as those of the Federal Housing Authority or Central Mortgage and Housing Corporation are not strictly building codes, but they have the same effect, and for our purposes may be grouped with building by-laws.

The Author: Robert De Grace, Past-Chairman of the Eastern Canadian Section, is Executive Vice-President of the Canadian Institute of Timber Construction.

[1] Presented at Session II, Wood Preservation, FPRS 14th National Meeting, June 6, 1960 in Montreal, Canada; approved for publication September 9, 1960.

Model Codes

When a municipal government sets out to establish a by-law, a representative committee is usually appointed, consisting of engineers, architects, building contractors and others who have knowledge not only of the field of building construction but of the requirements of the municipality. Because building codes have become so complicated, and require such specialized knowledge, the committee will often consult one of several "model codes" which have been prepared by experts as recommendations applicable to any municipality. Such model codes are widely recognized and respected, but they have no legal force until they have been adopted locally as a by-law.

In the United States there are four principal model codes:

1. National Building Code, prepared by the National Board of Fire Underwriters.
2. Uniform Building Code, prepared by the International Conference of Building officials.
3. Basic Building Code, prepared by the Building Officials Conference of America.
4. Southern Standard Building Code, prepared by the Southern Building Code Congress.

In Canada, we have only one such model code, the National Building Code of Canada, prepared under the administration and coordination of the Division of Building Research of the National Research Council.

The organization of the National Building Code of Canada will serve as an example of how such model codes are prepared. An "Associate Committee" on the National Building Code reports directly to the National Research Council. Under the Associate Committee fall four groups who advise the Associate Committee on specialized subjects: structure, fire, health, and housing. When it becomes necessary to prepare a revision to the code, a special revision committee is set up.

These various committees are composed of individuals drawn from industry and public life to represent a fair cross section of producers and users of building materials with balanced geographical representation. In the Advisory Structural Group, for example, there are seven architects and consulting engineers, three building officials, six representatives of material suppliers including industry associations, one general contractor and two engineering educators. They are drawn from British Columbia, the Prairie provinces, Ontario, Quebec, Manitoba, and Nova Scotia.

The municipal committees may use the model code either as a basis for the writing of their own building code, or for adoption completely or in part by reference. Except for the largest cities, municipalities can seldom take the time and effort, or provide the specialized knowledge, necessary to establish a building code from the beginning. Roughly, a third of the population of Canada falls under building by-laws that have adopted or are based upon the National Building Code of Canada.

The enforcement of a building by-law is delegated to a building official, whose title may be building inspector, deputy building commissioner, engineer of buildings, or something similar. He is responsible for the administration of the by law, issuance of building permits, and for examination of plans and inspection of buildings during construction to assure that the by-law is adhered to. To aid him interpret the by-law and judge proposals for materials or methods not specifically covered, a review board or committee is usually set up. Such a committee may also consider amendments or revisions to the by-law.

Usually the building official goes strictly "by the book", since his responsibility is great. He seldom can do otherwise, since he must enforce the law. He looks to the Board to distribute the responsibility for special interpretations or decisions.

Historic Codes

The responsibility of code officials, and the codes they administer, are a heritage from earliest civilization. Often we think the codes themselves must have been handed down from the Neanderthal man, but there is a historic, if not logical and rational, reason for every code provision.

Grade marking, for example, was first known about 5,500 years ago. In ancient Chaldea, the birthplace of early civilization, historians and archeologists found hinge sockets and bricks inscribed with marks believed to have been made under the approval of the king from the standpoint of public safety and utility.

The earliest known written building code was that of Hammurabi, King of Babylon, dated 2000 B.C. In it he says:

"229. If a builder has built a house for a man and his work is not strong, and if the house he has built falls in and kills the householder, that builder shall be slain.

230. If the child of the householder be killed, the child of that builder shall be slain.

231. If the slave of the householder be killed, he shall give slave for slave to the householder.

232. If goods have been destroyed, he shall replace all that has been destroyed; and because the house that he built was not made strong, and it has fallen in, he shall restore the fallen house out of his own material.

233. If a builder has built a house for a man, and his work is not done properly and a wall shifts, then that builder shall make that wall good with his own silver."

In ancient Rome, in 27 A.D., we are told of a certain Atilius, "man sprung from the lowest classes of the city," who obtained the right to build a temporary wooden amphitheatre. When an enormous crowd took their seats an the stand to enjoy an exhibition, the whole structure gave way with a terrific crash and buried the entire assembly. Reports were that the dead and wounded amounted to 50,000, an exaggeration, I would think. Atilius was not slain, however, —merely banished.

Such ancient codes were "performance" codes. A performance code is one that defines the result to be gained, leaving the builder with the widest possible latitude as to materials and methods. A specification code is one that states sizes and kinds of material and method of construction.

Following the Dark Ages, specification requirements began to appear, some form of inspection was instituted and punishment of malefactors became less severe. In London in 1189 street cleaners were the building inspectors, and were instructed to report irregularities "to the alderman, that he may make due redress therefor."

Following the great fire of 1666 in London, Parliament passed a law setting forth the "Scheme of proportions and scantlings for stories, walls and timbers for the building of lesser and larger houses within the city of London." Here we find the first classification of buildings; the law allowed for "sorts of buildings" according to the kind of lane or street on which the building fronted. It gave the sizes of timber, joists and rafters for various spans for floors and roofs; required that all roofs, window frames and cellar floors be made of oak, and among other things that "no timber be laid within the tunnel of any chimney upon penalty of the workmen of every default ten shillings, and ten shillings every week it continues unreformed." This was a "specification" code.

Building codes today have thousands of years of precedent and experience behind them. When facts about the required performance were unknown,

rules of thumb or the best judgment of the code producers were used.

We have progressed a long way. We have found facts through research which lead us closer to an ideal: the construction of buildings having the greatest possible economy of labor and material, but with assurance of complete adequacy. We find performance requirements steadily increasing as our codes are revised. We find research establishments seeking facts on which to build better codes.

But we still make estimates based on judgment and write them as law; we still copy and recopy old requirements in succeeding revisions. Only time and research can provide the needed facts.

It is clear that codes must require certain qualities, and that their requirements must be enforced. What then, can be done to improve wood's position; how can it acquire qualities consistent with the requirements for the public good laid down in building by laws? Let us first look objectively at the properties of our material, assessed on the credit and debit sides of the wood ledger:

Characteristics of Natural Wood

Credit	Debit
Aesthetic Qualities	
Pleasing to touch, sight, smell. Creates a warm "homey" feeling.	Weathers, darkens, may splinter, check, split, warp or twist.
Strength Qualities	
High strength for its weight.	Bulky; members must be relatively large in cross section.
Durability	
Not generally subject to attack by corrosion or most chemicals; will not spall.	Under some conditions subject to decay, insect attack, marine borers.
Physical Properties	
Very low thermal expansion. Very resilient. Fair acoustic properties.	Shrinks and swells with changes in moisture content. Great variability among species and within any one species.
Fire Performance	
Good (heat) electrical insulator. Slow burning when bulky.	Combustible; adds fuel to fire. Aids in spreading flame to adjacent combustibles.
Supply	
Easily obtainable in most areas.	Many different grades and species are confusing.
Practical Qualities	
Easily handled. Easily worked.	Bulky to ship. Breakable. Familiarity breeds contempt; workability often results in misuse.

If we were dealing with synthetic materials, such as metal or plastics, we would seek ways to improve our product to minimize its debits and capitalize upon its credits. Since we are dealing with a natural material, we must find ways to modifying it without destroying its good natural characteristics. Suppose we tabulate the debits and consider the correction which is being applied, or might be applied, to each.

Modifying Wood's Characteristics

Debit	Correction
Weathering color.	Impregnation or coatings.
Checks, splits, warp, or twist.	Care in kiln-drying, installation at proper moisture content, impregnation.
Bulkiness.	Nothing.
Decay, insect attack, marine borers.	Pressure impregnation.
Shrinkage and swelling.	Chemical impregnation.
Variability.	Nothing; aim for simplicity in specifications.
Combustibility, flame spread.	Pressure impregnation, fire-retardant coatings.
Confusion of grades.	Simplify; coordinate.
Misuse.	Education.

Here we see some of the qualities of wood which are reflected in building code restrictions. It is in these areas that we can act to make wood acceptable to building code producers and administrators, and thus acceptable to the public. In so doing, we are "upgrading" the product. We may add to its cost, but if we can add a greater amount to its value, the "upgrading" is warranted.

Grade Marking

Recently the Federal Housing Authority established rules requiring lumber to be marked with the grade. This is an important and far reaching milestone in the relationship of forest products to building codes.

If the cost of grade marking is more than offset by the increased value of the product in consumer acceptance and in the ability of the building official to be confident of the quality of materials, then the improvement of the product by grade marking is justified.

The grading of lumber, unlike many competing materials, is carried out visually. The means of grading is as yet unstandardized. Each regional association has its own grading rules and its own designations of grade name. Even the grading requirements differ in form; those used in the West are generally permissive: they permit certain maximum defects; those used in the East are usually descriptive: they describe a typical piece of the grade. Grading of lumber calls for great skill; recognized graders have become qualified through study, training and experience. Yet the building inspector, unskilled in grading, must verify on the job that the grades being installed are those called for by the job specification.

Lumber manufacturers have been reluctant to establish universal voluntary grade marking. They have good reasons. You cannot cut pieces of many grades, under our present complicated grading rules, either lengthwise or cross-wise, without changing the grade. A piece can be graded down or rejected under one rule, yet be quite acceptable under another. Certificates on lots of lumber are seldom adequate; the building inspector finds it difficult to assure that the piece being installed on the job is actually the one covered by a certain certificate.

Comprehensive grade marking under present rules calls for a marking which would be continuous throughout the length of the piece, would designate the width and length of the piece when graded, and would show species, grade and the applicable rule.

Research Needed

As the forest products industry demands higher allowable stresses for lumber, we find an increased need for accuracy in grading and assurance that the proper grade is being used.

Here are many opportunities for research to improve our product. Market research could determine the needs of the public; whether or not the vast number of grades now produced is really necessary. Statistical research might determine whether or not present rules could be simplified. Such simplication could result in easier grade marking. Universal grade marking of a simplified product could result in better understanding by the consumer and hence in readier acceptance by code producers and building officials.

Our present complicated grading rules give rise to another problem whereby the use of lumber could be improved by statistical studies. Yard lumber differs from stress graded lumber principally through lack of a slope of grain requirement. Building designers would like to be able to assign an allowable stress to yard lumber, but this can be done now only by guess. Yet statistical studies alone would determine the frequency distribution of various slopes of grain found in commercial lumber, and therefore what working stress could logically be applied to yard lumber. Here we can "upgrade" our product through an improvement in our knowledge of its characteristics.

Limitation on Wood Piling

Specification requirements often call for the use of stone or concrete in ground contact. These are handed down from earlier restrictions when it was found that untreated wood would decay and cause the building to deteriorate rapidly. Yet pressure impregnation of wood, a result of research, prevents deterioration. The improved product, however, must be proved of adequate quality if code producers are to change their requirements.

Timber foundation piling for large buildings is often assigned arbitrary maximum loads, sometimes as low as 12 tons per pile. Yet in actual load tests the load-carrying capacity is seldom found to be less than 50 tons and often 100 tons or more. Such limiting requirements are the result of copying and recopying earlier regulations.

Empirical limitations were once placed on wood piling, because of lack of knowledge about soil mechanics, lack of knowledge as to the strength and durability of timber, and a tendency to be over-conservative when materials were plentiful and cheap. As special types of steel and concrete piling were developed to provide greater durability and greater load-carrying capacity these qualities were vigorously promoted to the detriment of timber piling. Yet pressure-treated wood piling are now known to be, for all practical purposes, permanent; they are capable of carrying loads usually limited only by the soil.

Unjustified limitations on wood piling in building codes can be corrected. It requires convincing proof of durability and load-carrying capacity. Such proof is available, but it can be made more convincing by more extensive test loadings—all carried to ultimate load and not stopped when the test load is just enough to justify the arbitrary code limitation.

Fire-Retardant Treatments

No discussion of codes would be complete without discussing the fire problem. Wood is recognized by fire protection experts as being a good fire risk but building codes persistently restrict its use. Other materials are restricted too, but the greatest limitation seems regularly to be placed on wood.

Combustibility is the key. It is interesting to note, though, that many expert committees have studied for years without agreeing on a definition of a combustible (or non-combustible) material. In some codes a non-combustible material is defined as one having a flame spread of less than 25, under the standard underwriter's tunnel test.

Pressure treatment with some fire-retardant chemicals makes it possible to bring the flame spread rating of wood from about 100 down to 25 or less. In building codes which define non-combustible as having a flame spread of 25 or less, such fire-retardant pressure-treated wood can be used, and it will meet the same height and area limitations as steel. Thus a whole new market is opened up for fire-retardant-treated wood, as a result of improvement based on research.

Heavy timber already enjoys a good reputation and fair construction limitations in many codes. Pressure treatment of heavy timbers with fire retardants might make it possible to improve the code limitations on heavy timbers.

AT MONTREAL, author De Grace, flanked by E. S. Harrar (left) and T. S. Veazey announced plans for an annual Eastern Canadian Section Student Awards Program.

Unfortunately, the decision as to what characteristics are actually required of a material for acceptable fire performance are still largely matters of opinion. Research now being done by insurance companies, government laboratories, the National Research Council, and other interested groups is rapidly reaching the point where a more rational approach to fire requirements may soon be expected.

Research might make it possible to reduce the flame-spread rating of wood still farther, and at the same time add other desirable characteristics. Perhaps a single impregnation might at once reduce the combustibility and flame spread of wood to the lowest possible limit; make it almost completely invulnerable to decay, insect, and marine borer attack; and reduce its properties of shrinking and swelling with moisture changes to insignificant proportions. The result would really be a changed wood, some new product whose characteristics have been so altered by pressure impregnation that it retains all of the natural benefits granted by nature, suppresses the undesirable natural characteristics, and imparts new qualities which make it better than any of the synthetic substitutes yet invented.

Structural Research

Structural research can also be important in improving the position of wood in building codes. When sufficient facts are not available, some arbitrary limitation is sometimes pressed into service. The limitation is then left without further study, perhaps because other things appear to have greater importance. It is copied again and again into codes and specifications until it has invested itself with the authority of precedent.

For example, certain maximum breadth-to-depth ratios have been established for certain degrees of lateral support, in construction using timber beams. The most economical wood beam, to support bending loads is narrow and deep. However, with code requirements limiting the height of such beams as a function of their breadth, the maximum possible economy is limited.

Some sketchy, exploratory studies have indicated that much deeper beams than those limited by codes can be used. It is known that the source of the code information is based upon judgment. But until we study the characteristics of deep, narrow beams by comprehensive research, we have no real information that can be used to secure more equitable building code requirements.

There are many ways in which wood can be improved to gain more agreeable provisions in building codes. Modern product development calls for tailoring the product to fit the needs of use as nearly as possible. It is far more than trying to get more and more concessions in building regulations. A clear understanding of the point of view of the code producer and building official is as essential to successful negotiation and product development as is an honest desire on the part of code writers and enforcers to encourage improvements in building products and methods.

Pendulum Cutting Test Standardization

AND PERTINENT CUTTING FUNDAMENTALS[1]

L. H. REINEKE

Forest Products Laboratory,[2] Forest Service
U. S. Department of Agriculture

PENDULUM DYNAMOMETER at the Forest Products Laboratory for measuring energy consumed in cutting.

Standardization of equipment is proposed in a two-part presentation. In Part I, the author discusses fundamentals of fiber severance and chip formation. Part II, to be printed next month, concludes discussion of chip formation, and describes three forms of a standard cutting tool that merit consideration.

CHARDIN (1),[3] IN HIS "Utilization of the Dynamometric Pendulum in Research on the Sawing of Wood," has made an excellent and timely proposal for an international standardization of the dynamometric pendulum tests used in studies of the sawing of woods. As he points out, this field is too large for complete coverage by any one laboratory. With uniform techniques, the findings of each laboratory could complement those of others, and an interchange of findings would hasten the closing of gaps in our knowledge of sawing.

In his presentation of the proposed standard technique, Chardin briefly reviews present basic knowledge of sawing and discusses several gaps in our knowledge of sawing fundamentals. The existence of such gaps raises the question of whether or not this is the proper time to standardize our dynamometric pendulum tests. As we fill in these gaps, the basic information obtained may lead to valuable improvements in technique.

The Author: Les Reineke earned his BS in forestry from Cornell University, and took a year of graduate study at the Univ. of California. He joined the FPL in 1942.

Flexible Preliminary Standard

Improvements cannot be awaited indefinitely, however, for the last word never will be said. Preparation of a groundwork calls for concerted effort by all concerned, and may be expedited by adoption of a provisional and somewhat flexible standard technique.

Some flexibility in the preliminary standard is necessary for two reasons. First, different systems of measurement are used by different countries, and desirable as it is, universal adoption of the metric system is still far in the future. Even in countries using the metric system, the use of the rather unsystematic "gage" for stating the thicknesses of saw blades is widespread, and a number of countries on the metric system employ the inch and foot unit of measurement for export lumber. Laboratory use of the metric system is entirely feasible, but industrial and practical requirements must be met where another system of measurement is in use.

The second reason for a flexible preliminary standard is that dynamometric pendulums are not numerous, and each has been designed individually. The individualities of design, such as pendulum length and mass, methods of holding the tool and the wood sample, methods of metering the cut and the unit of increment available, and methods of determining and recording energy, may not be susceptible to modification. Further, all existing machines may not be adaptable to operation under one standard procedure. Pendulum mass and length and the cutting radius, which is not necessarily synonymous with pendulum length, are probably of greatest concern. Length affects tool velocity, mass affects both the deceleration in the cut and the magnitude of the angle that measures the energy absorbed, and cutting radius affects the change along the cutting path of the angle between cutting path and fiber direction of the test specimens. This change in angle is normally small with the pendulum lengths and test specimen widths commonly used, but could be considerably larger if wide specimens and short cutting radii were used.

[1] Presented by title only at Session VI, Wood Machining, FPRS 14th Annual Meeting, June 5–9, 1960, in Montreal, Canada.

[2] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

[3] Numbers in parentheses refer to the Literature Cited at the end of this paper.

These obstacles to an immediate standardization of technique are by no means insurmountable. The common interest of all laboratories concerned is the determination of basic relationships between tool and wood in sawing or other cutting operations on wood. Regional differences that exist in species, timber sizes, and industrial practices, may introduce conflicting goals in extending basic procedures to the solution of practical problems. It is reasonable to suppose that such problems can be embraced within a reasonably comprehensive procedure standard. If this view is acceptable, there is no reason to delay taking preliminary action, by correspondence and meetings, to evolve a flexible provisional standard for dynamometric pendulum tests for wood.

Gaps in Fundamental Knowledge of Cutting

In advance of such action, some observations on the gaps in our knowledge of fundamental actions in cutting wood may be worth recording. In his presentation, Chardin observes that all pressure of the wood on a sharp cutting edge calculated from the area of the edge and the theoretical fiber severance force is far in excess of any force that could be resisted by present tool materials without damage. Naturally, if such pressures are excessive for steel or other tool materials, they must be even more excessive when referred to the wood that applies that force to the tool edge. Obviously, further consideration must be given to the action that takes place in severing wood fibers with a cutting edge.

Fiber Severance in General: Basically, the maximum pressure that wood can exert against any intrusive object, such as a cutting tool, is initially no greater than its resistance to compression or bending. After the initial penetration, the resistive force is augmented by friction between the wood and tool and by resistance to further deformation and shearing, but the major portions of these forces are developed principally after fiber severance has occurred. The ideal severing tool would have an edge fine enough to enter the spaces between the wood molecules. Such a tool, however, would have to be made of materials with molecules smaller than the spaces between the wood molecules, or the molecules comprising the cutting edge would have to be tapered. Since this is impossible, the cutting edge must press upon the fibers as structural units cemented together and cause local deformation until molecular cohesion is overcome and the fibers break.

If it is assumed that the plane of the cut is perpendicular to the fiber axis, a possible sequence of action in fiber severance may be this: At the instant of contact between the cutting edge and the fiber, no force on the tool is required. Any subsequently applied force that tends to move the tool toward the wood will encounter resistance from the wood, but such resistance can be developed only by deformation of the wood. Initially, this deformation will be in the form of a bending of the cell wall at the region of contact with the tool edge. For convenience, the cell may be considered as having a top and bottom wall and two side walls, with the cutting edge moving from top wall to bottom wall. Since increasing tool pressure causes further penetration, a countering resistance builds up as the top cell wall bends further. When the top cell wall eventually reaches the bottom wall, on the opposite side of the cell cavity, additional bending resistance then is supplied by this bottom wall and the top wall of the next cell below it in the direction of cut. As the bending of the top wall proceeds, the side walls add additional resistance to penetration of the edge. The top and bottom walls are equivalent to shallow beams of low stiffness, but the side walls are, in effect, deep beams of much greater stiffness. Bending of the top and bottom walls is discrete in character, since successive bottom or top walls add their resistance only when the overlying wall has moved across the cell cavity. The reaction of the side walls, however, is more nearly continuous from the instant of contact, and their bending tends to deform the underlying cells, thus distributing the applied force over a widening zone.

Concurrent with this distribution of the force applied by the cutting edge, another distribution of force may be occurring over the faces of a wedge-form tool.[4] To each side of the tool, the fiber may be considered as a cantilever beam loaded at the end by the cutting edge force and having a distributed negative loading or reaction exerted by the support of the underlying fibers. If the fiber's angle of deflection at the cutting edge is large enough, the fiber will be in contact with the faces of the tool and will impart some of its resistance to the area of contact, thereby relieving the fiber stress under the edge by an equal amount. If the wedge angle of the tool is large, the resistance distributed over the wedge faces may prevent the fiber stress under the edge from rising to the level at which the fiber will rupture, and the tool will merely bend the fiber as in an indentation.

Since the bent fiber lies along the wedge surfaces of the tool, its length must increase, as it now forms two sides of a triangle whose base is the original unbent length. Eventually, as penetration of the tool increases, the fiber must fail in tension at the weakest or most highly stressed point within the zone affected by the tool pressure. This point of failure is indeterminate because the distribution of forces is affected by whatever irregularities may exist in the support by the underlying cells.

Fiber Severance in Sawing or Shaping: The picture changes somewhat when the tool is applied close to the end of a fiber (approximately ¼ inch or less), as normally occurs in ripsawing or in shaping end grain. In cutting close to the end of the fiber with a tool that has a large wedge angle, the tension force is accompanied by shear parallel to the fiber, and the bending force has a component that tends to produce cleavage. Because of the lower shear and cleavage strength of wood, the short area between the end of the fiber and the cutting edge may be too small to develop adequate resistance to the shear and cleavage stresses imposed. The outer end of the fiber may then shear longitudinally or cleave from the underlying fibers. The structure of most woods is such that cleavage resistance varies progressively throughout an annual ring, with the result that the line of cleavage may occur in underlying fibers at some distance from the top fiber. Such cleavage or shear may occur at the outer end of the fiber before severance is completed. Such severance is completed through the agency of stresses in the portion of the fibers on the other side of the knife and in the fiber underlying the cutting edge.

The action that is characteristic of a large wedge angle changes as the wedge angle becomes smaller. When the wedge angle is extremely small, the deflection of the fiber at the cutting edge may fail to match or exceed the angle of the tool faces, and there will be no relief of stresses directly under the cutting edge by partial transfer to the tool faces. As a result, the bending tension stresses reach the stress limits of the fiber, and it ruptures directly under the cutting edge. The volume of wood deformed by the wedge is much smaller for small wedge angles than for large wedge angles; hence, less energy is required when cutting with small wedge angles.

[4] The assumed action is similar to that of a double-wedge tool, such as a pocket knife, as it starts a rectangular notch in a board edge some distance from the end.

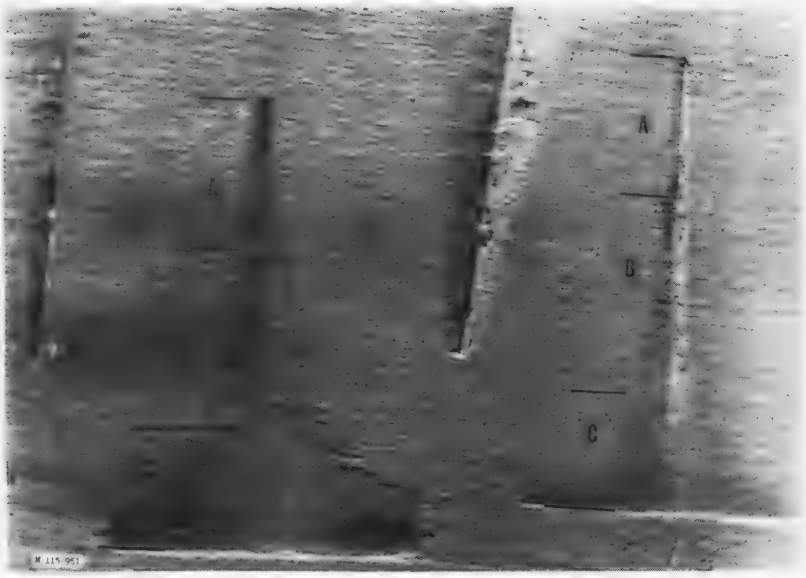

Fig. 2.—Indentations made in basswood by all-angle test knife. Fiber rupture occurs at the knife edge in Zone A, and along the indented surface between knife edge and shoulder in Zone B. If any rupture occurs in Zone C it appears at the shoulders of the indentation. Knife edge angle at the extreme of the narrow end of the indentation is 20°, and increases to 170° at the extreme of the broad end.

Effect of Chip Formation on Fiber Severance: Further penetration of the cutting edge as the initial force is continued will result in chip formation when the cutting edge is near the end of the piece of wood; otherwise, the tool will merely penetrate the wood very much as a nail penetrates. With a small wedge angle, rupturing stresses at the point of contact between the tool edge and fiber are not entirely imposed directly by the edge of the tool when that edge is close enough to the fiber ends to produce a chip. With sufficient penetration, the severed fibers that form the chips will come into contact with the tool face. They will then be subjected to pressure by the wedging action of the tool and by the frictional drag. This pressure will be distributed through the chip to and beyond the fibers at the tool edge, and will influence the stress on those fibers up to the instant of severance. Since the wedging action of the tool face is in a direction more or less parallel to the fiber axis (in cutting across end grain as in ripsawing), the force transmitted through the chip tends to increase the tension on the fibers being severed at the tool edge. The frictional force between chip and tool face, which is more or less parallel to the cutting direction, tends to reduce bending (and therefore stress) in the short end of the fiber being cut.

Fig. 1.—Test wedge or knife, with the total edge angle varying at a uniform rate from 20° at the front to 170° at the rear.

The actual directions and magnitudes of these forces, transmitted through the chip are only of academic interest, since they merely displace equal forces of other origins without changing the ultimate stress at rupture. The factor that is significant, however, is the pulsating character of the net force transmitted through the chip. As the tool penetrates, the force it transmits through the chip increases also, but at some point the resistance of the chip to bending is exceeded by the thrust applied by the tool face. The chip then shears off along the fibers in an irregular surface a variable distance back of the cutting edge. The force on the chip, having risen gradually, then drops suddenly to a value that depends on the shape of the break and its distance from the cutting edge.

The double-wedge cutting edge previously mentioned is, of course, broadly different from the normal saw-tooth edge. Nevertheless, the action of a sharp saw tooth can be derived by considering the clearance-angle side of the tooth as having a zero wedge angle, and the attack or front face as having a moderate to large wedge angle facing the short end to be removed as a chip. Actually, however, fiber severance occurs with only small penetration of the tool. In the corresponding short distance from the cutting edge, even slight wear or dulling (4) produces an edge with much of the character of a double-wedge cutting edge.[5]

An All-Angle Severance Test Tool: Physical evidence of this description of fiber severance is presented by tests with a wedge cutting edge in which the included angle between the faces varies at a uniform rate from 20° at one end to 170° at the other end (Fig. 1). When forced into a wood surface by either a slowly applied pressure or by a sharp blow, the resulting indentation causes a deformation and failure of the wood that varies in character as the wedge angle changes. The characteristic response to a range of wedge angles can be observed on wood of any species, but homongeneous wood structure facilitates observation.

A typical example in a homogeneous wood, basswood (*Tilia americana L.*), is shown in Fig. 2, in which depths of penetration of the tool were 0.018 and 0.051 inch for the two complete indentations shown. Zone A includes those edge angles that produced fiber rupture directly under the edge. In Zone B, fiber rupture occurs on the sides of the indentation, near the bottom for the smaller edge angles and approaching the shoulder or boundary of the indentation as the edge angle increases. In Zone C, no fiber rupture appears within the indentation, and little or no rupture appears at the shoulders (disregarding that due to the corners and back edge of the tool). The angles included in each zone are essentially the same, despite differences in depth of penetration of the tool. The pattern is reproducible with good accuracy on the same piece of material, especially with respect to the maximum edge angle at which rupture occurs directly under the edge. For winged elm (*Ulmus alata* Michaux), the maximum edge angle averaged 105.2° for 10 readings on 1 specimen with a standard deviation of only 3.78°, while for evergreen magnolia (*Magnolia grandiflora* Linnaeus), the average angle for 9 readings on 1 specimen was 69.2° with a standard deviation of 3.32°.

[5] Figs. 38 and 40 of reference (4).

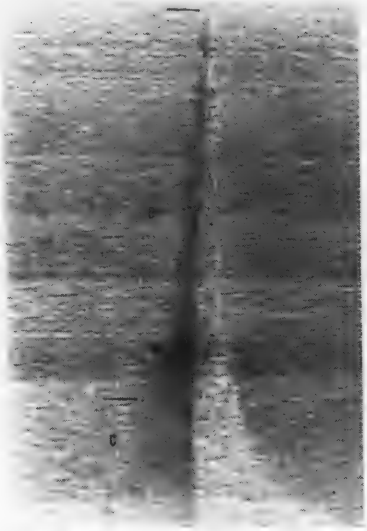

Fig. 3.—Test knife indentation in the thin-walled cells of yellow-poplar shows no fiber rupture at the knife edge, hence there is no Zone A, but the B zone is long.

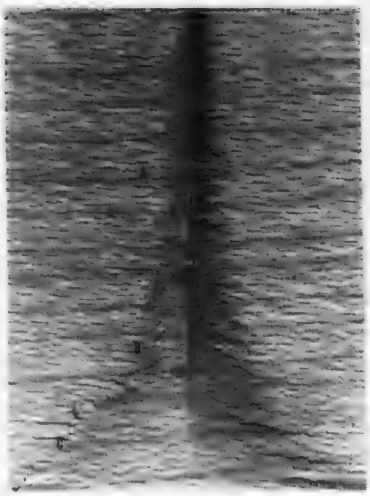

Fig. 4.—For sugar maple, the thick-walled cells increase the bending stress at the knife edge and cause rupture at the edge over a wide range of knife-edge angles; hence, the A zone is long and the B zone is shifted in the direction of larger knife angles.

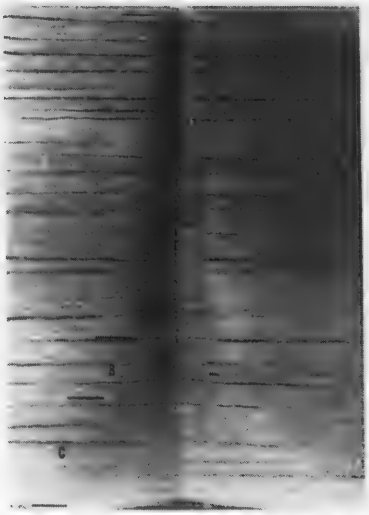

Fig. 5.—The toughness of hickory, in addition to its hardness and strength, increases the maximum knife-edge angle producing rupture at the knife edge, giving a long Zone A and a very short Zone B.

Within a species, the average angle may vary with density or moisture content. The variation between species results not only in different maximum angles for edge rupture (length of the A zone), but also in the relative lengths of the other two characteristic zones. A pattern that lacks the A zone of Fig. 2 is obtained with a different homogeneous wood, yellow-poplar (*Liriodendron tulipifera* Linnaeus), as shown in Fig. 3. Apparently, in the thin-walled cells of yellow-poplar heartwood, the net bending stress at the knife edge is less than the bending strength of the fibers, and they rupture in tension along the walls of the indentation. Zone B is rather long because of its extension to the front end of the knife, but Zone C, free from ruptured fibers, is clearly evident.

A rather hard wood, sugar maple (*Acer saccharum* Marshall), shows the usual pattern distinctly. The cell walls of this species are much thicker than in the yellow-poplar of Fig. 3, and higher bending stresses may be expected for a given edge angle, which result in rupture under the edge at rather large angles. The length of Zone A in Fig. 4 illustrates this feature for sugar maple. The large-angle end of zone B may be expected to extend farther into the region of large edge angles, leaving a rather short C zone. In this example, Zone B illustrates nicely the tendency for wall ruptures to progress from the bottom to the shoulder of the indentation as the edge angle increases.

Toughness added to strength and hardness tends to shorten or eliminate the B zone. The tough wood of hickory, (*Carya* Nutt) shows an extensive range for Zone A in Fig. 5, signifying a high tensile strength or a ductility that permits the lesser bending forces for large edge angles to reach the rupture level before the limits of stretch and tensile strength are reached.

The indentations of Figs. 2 to 5 show the width of the zone of deformation in relation to the wedge angle. For a given depth of penetration of the cutting edge, the area of wood deformed per unit of cutting edge length, and the work required, are functions of the wedge angle. Depth of deformation appears to be much less closely related to wedge angle, as suggested by Fig. 6. Fig. 6 illustrates the effects of some of the bending, shear, and compressive forces produced in cutting close to the ends of fibers as in a normal saw chip. The tool edge is 0.17 inch from the end of the redwood sample (*Sequoia sempervirens* (D. Don) Endlicher), and penetrates it 0.155 inch. The entire area, except at the extreme right of the picture, is underlaid at considerable depth by compressed fibers with diagonal "fingers" of compressed fibers following the direction of the medullary rays that probably form zones of slightly lower compressive strength.

At the 20° edge-angle end, at the right in Fig. 6, there are two relatively large radial splits. To the left of these, a zone of tangential splits with scattered shorter radial splits extends to A, where the edge angle is 144 . The openings of the splits diminish toward the left, becoming almost invisible at A without a good magnifying glass. To the left of A, the angle of the tool face matches or exceeds the deflection angle of the fibers at the cutting edge, and the tool face bears on the outer portions of the fibers with sufficient pressure to counteract any cleaving force developed by the cutting edge.

Cleavage in Chip Formation: The way in which the cleavage force develops when a chip is cut may be somewhat obscure and may be a complex of several forces. The action may be likened to that of a lever with its fulcrum between the applied and resultant forces. Each fiber can be considered to be such a lever at the instant of cutting. The applied force is the force of the cutting edge, the resistance of the underlying fibers serves as a broad, elastic fulcrum, and the resultant force acts on the free end of the fiber, but is resisted by cohesion to the underlying fibers unless the force is greater than the cleavage strength. As the cutting-edge angle becomes larger (less sharp), the fiber is bent less during cutting and the applied force is distributed over an increasing length of the lever (fiber); the effective center of the fulcrum moves outward somewhat, and full leverage that results in cleavage may not be developed until the edge has penetrated further and begun to form a chip. With very large edge angles, the additional penetration of the edge may bring the outer part of the tool face down onto the free end of the lever or fiber, applying a counteracting force to prevent cleavage.

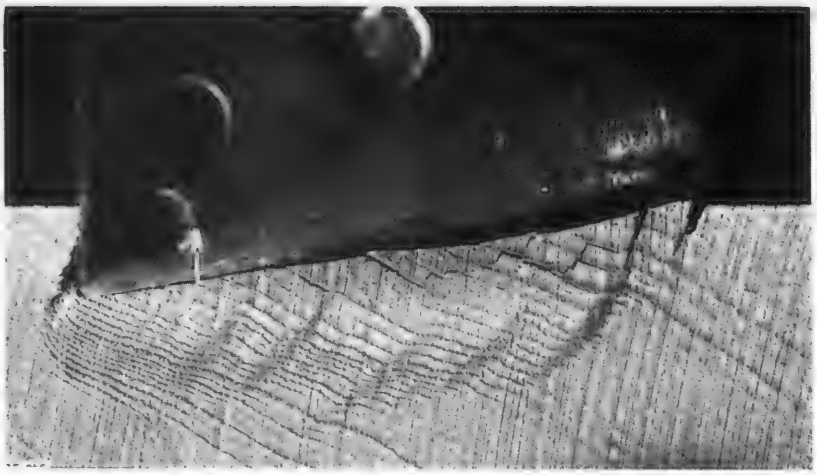

Fig. 6.—Pressure effects under the all-angle test knife near a cut surface are fairly uniform in depth for all but the smallest knife angles at the right. To the left of A, where the knife angle is 144°, the tool face bears on the wood surface and prevents the cleavage that occurs along the annual rings to the right of A.

A simple demonstration of this action can be made by placing a stick the length of the hand on a thick piece of sponge rubber at least equally long. By pressing heavily with the edge of the hand crosswise to the stick and as near as possible to one end, the opposite end will rise far above the rubber surface; a pressure nearly equal to that of the hand would be needed to return the uplifted end to the rubber surface. This equalizing force is comparable to the force that tends to produce cleavage. If the heel of the palm is now placed at the end of the stick, with the hand pointing upward at 45° to the rubber surface and toward the opposite end of the stick to represent the face of a wedge of moderate angle, the free end will rise less and require less force to return it to the rubber surface than was previously demonstrated. This indicates a lower cleavage force, but one that still may exceed the cleavage strength of a wood.

Finally, if the angle of the hand is reduced to 5° or 10°, the free end will rise only slightly or may not even leave the surface at all; the fingers may touch and apply pressure on the free end before or soon after it starts to rise. The small rise represents a small cleavage force below the cleavage stress limit of a wood, and the contact of free end and fingers represents full contact between fiber and tool face, preventing further increase of cleavage stress.

Definition of Fiber Severance: If the foregoing description of the process of fiber severance can be accepted as valid, in whole or even in part, the ideal of severing fibers by inserting a wedge that has a mathematically perfect edge between the fiber molecules and overcoming their cohesion by a wedging action must not be claimed as a realistic description of severance by a common cutting edge. Instead, fiber severance should be designated as a process of rupture precisely localized by forces applied at and in the near vicinity of the edge of a cutting tool. Severance force and energy should include all forces or energy transmitted to the fibers by the tool faces (which include the edge also) up to the instant of rupture of each fiber. The tool area through which these forces are applied to the wood is indeterminate and probably fluctuating.

Measurement of Fiber Severance Force: Measurement of this severance force independent of the normally coacting sawing forces may be possible by preparing a stack of veneer strips slightly narrower than the cutting edge to be used and thinner (one-twentieth of an inch or less) than the normal interval between crosswise breaks in a normal chip. Glue applied to the bottom end of the veneer stack, after assembly and clamping, will permit feeding the stack as a book-like unit.

The use of veneers is equivalent to precrumbling the chip to eliminate the forces involved in the crosswise breaking of the chip. If the veneer is uniform in thickness and smoothly cut, and the stack is clamped tightly enough to approximate solid wood without excessive compression being introduced, a thin chip taken across the ends of the stacked veneer strips will be free of the side shear, crumbling, and sawdust friction forces present in normal sawing. To find the severance force alone, additional factors to be eliminated are: 1) the readily computed energy used in imparting to the chips a velocity equal to tool velocity, and 2) the energy absorbed by friction between the veneer layers within the chip, which should be negligible for the thin chips that would suffice for measurement of severance force.

The assumption of negligibility of friction between the severed layers of veneer may be checked by using a number of veneer stacks, each made up of veneer of a different thickness, one-twentieth of an inch or less. Three stacks, one with veneers of maximum permissible thickness, one with veneers half that thick, and the third with veneers of one-fourth maximum thickness, would show a progressive change in severance plus friction energy, because of the progressive change in number of veneer surfaces. An additional known frictional area can be introduced by using several chip thicknesses in such severance measurements. In preparing the veneer stacks, care must be taken to use veneer from a large number of logs for each veneer thickness in order to reduce error from variation in material, since several thicknesses of veneer are rarely cut from the same log.

Isolation of Cutting Forces

The isolation of the separate forces that contribute to the total force involved in sawing, such as fiber severance, is perhaps of minor direct interest in the practical use of saws. Knowledge of the origins of these forces, their magnitudes, and their interactions, however, may be of much direct value in saw-tooth design, in saw operation, in the simplification of tests of the cutting characteristics of various woods, and in the ease with which such basic, practical information may be applied.

Lateral Forces in the Chip: Chardin (1) has contributed an analysis of the forces exerted laterally on the sides of a chip being made by a narrow saw tooth, and has developed a method of determining the magnitude of the lateral forces inferentially in the absence of direct methods of measurement. The existence of such lateral forces was indicated to Chardin by the tendency for the chip to widen as a narrow tool, like a saw tooth, made a shallow trenching cut at the surface. For subsequent cuts in the same trench or kerf, such a physical widening is prevented by the kerf walls which must, of course, resist such sidewise pressure by the incipient chip immediately prior to or at the instant of severing.

Standing alone, the widening of chips cited as an indication of later pressure might be inadequate evidence since planes of weakness along the medullary rays and minute drying

checks may cause the initial chip to lead away from the cutting path, but the premise is supported by the crosswise bending or "bowing" of chips deep in the kerf, reported by the author (6) in connection with studies of wear on a saw-tooth face. In these studies of saw teeth 5/16 inch wide (7.94 millimeters), further evidence of crosswise arching was noted in the form of chip fragments of appreciable length (¼ to ½ inch) that exhibited a permanent arching with the convex surface face upward, away from the tooth face.

These indications of lateral pressure on the sides of the saw chip suggest some force acting at the kerf walls in addition to the accepted shear and frictional forces, both of which act in the plane of the kerf walls. The additional force is perpendicular to the kerf walls and cannot increase the shear force. Any force on the kerf walls other than shear will only tend to increase stresses in the cells and thus reduce the resistance to shear. Conversely, the friction between the sides of the chip and the kerf walls will be increased by any pressure developed across the chip.

The origin of such pressure may be attributed to the pressure exerted by the face of the saw tooth as it advances against the resistance of the uncut wood ahead. Any incompressible elastic mass subjectd to compression along one axis will maintain its volume by expanding along the other two axes.[6] Wood, however, is compressible to some extent because of the voids (cell cavities) in its structure, but the compressibility varies with direction relative to the fiber direction, and is smallest in the fiber direction. At the same time, wood resists compression elastically with some volume adjustment by distortion of the cells, and a final volume change occurs through cell collapse when the ultimate compressive strength is exceeded. This crushing stage is not reached unless the hook angle of the tooth face is quite small. For the more common cutting conditions, the chip probably remains in the elastic range.

In ripsawing, the cut is made more or less across the end grain, and a short length of chip at the cutting edge can be visualized on an enlarged scale as a narrow, rectangular block of honeycomb. Such a structure is stiff and highly resistant to deformation by forces applied in the direction of the cells, but a force perpendicular to the cell axis would meet little resistance and cause a relatively large deformation. If the force is compressive and applied over the long sides of the rectangle of honeycomb, the block will become narrower. The resulting reduction in volume will not be compensated by any appreciable increase in the thickness of the block, because the high strength in the axial direction permits very little elongation. In the short or cutting-path direction of the honeycomb block, however, the cells are less resistant to compression. The deformation that creates the resisting force is a flattening of the cells. This corresponds to a change from circular to elliptical cross section for a pipe, with the shortened dimension in the cutting-path direction and the lengthened dimension parallel to the cutting edge. The aggregate increase in dimension parallel to the cutting edge largely compensates for the reduction in the cutting-path direction, thus tending to maintain a constant volume as long as the applied force does not reach the level at which the cell walls would buckle and collapse.

The dimensional changes in the honeycomb example cannot occur within the confines of a saw kerf. True, the top surface of the chip is unconfined, but dimensional change between the top and bottom surfaces of the chip is negligible. Dimensional changes in the cutting-path direction are produced by the saw-tooth face and the yet-uncut supporting wood. The remaining available direction for a volume-compensating change of dimension is across the kerf, but the kerf walls prevent such widening of the chip except by compression of kerf-wall cells. As a result, the deforming force is translated into a lateral pressure against the part of the kerf walls being formed at that instant.

Physical evidence of the existence of this pressure zone was obtained by impregnating the end of a piece of balsa with a hot, nonelastic, semifluid (petroleum jelly), and, after the wood was cooled, starting a cut across the end with a cutting edge equivalent to a swaged or "chisel edge" saw-tooth 3/16 inch wide. The plane of the cut was perpendicular to the fiber axis, as in ripsawing, and the pressures developed in cutting caused the petroleum jelly to extrude from the cell ends in response to the deformation within each fiber. The nonvolatile, nonliquid extruded jelly retained its distribution and contours indefinitely, even when the cutting tool was withdrawn. A typical pattern, photographed with the cutting tool still maintaining its cutting pressure, is shown in Fig. 7. The leading edge of the pressure zone is slightly convex in the cutting direction, and extends sideways beyond the line of the sides of the tool. The side extensions tend to be somewhat

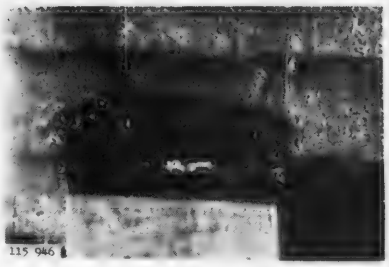

Fig. 7.—Cutting pressure by a swaged type of sawtooth causes deformation of the wood ahead of the cutting edge. The zone of deformation, shown here by the squeezed-out plastic filler used to fill the cells, extends sideways beyond the sides of the cutting tool.

greater in springwood than in summerwood, probably because the thinner walls of springwood cells are less stiff and permit more deformation under cutting pressure.

The zone on the kerf walls to which lateral pressure is applied would be inclined to the bottom of the kerf, probably at somewhat less of an angle than that of the face of the saw tooth, and centered at the instantaneous position of the cutting edge. The pressure zone will diminish rapidly ahead of the cutting edge, because the unsevered fibers in the kerf and its walls will distribute the forces widely within a very short distance. The zone behind the cutting edge also will diminish rapidly, because the newly cut portion of the chip rides up the face of the saw tooth and, within a very short distance, is above the level of the chip. Therefore, this newly cut portion is unable to apply any compressive force against the chip.

The effect of this moving lateral pressure zone may be no more than the equivalent of rolling a short cylinder under pressure along a kerf surface, but it may stress the kerf-wall cells sufficiently to reduce the force necessary for shearing the sides of the chip, or it may move the plane of failure slightly away from the ends of the cutting edge. Although the plane of failure may be at or beyond the ends of the cutting edge, this failure occurs at the point of maximum lateral pressure, with its corresponding compression of the kerf wall. This compression will cause springback of the kerf surface immediately after the cutting edge passes, and this springback requires some side clearance. For narrow saws, the lateral pressure zone is small and shallow, and the small amount of springback requires only a small clearance allowance. For thick saws, the deformation of the wide chip will extend the area and depth of the lateral pressure zone, resulting in greater springback that requires a greater clearance allowance.

[6] The relation between linear changes in dimension is expressed as the Poisson ratio.

Shear along its sides immediately establishes the chip as a thin ribbon or panel subjected to edge pressure, with a lifting force beneath it and frictional forces along each edge opposing that lift. Irregularities in the friction surfaces may result in setting up moments that tend to buckle this panel. If such moments are downward, referred to the panel (chip) center, they will be nullified by the support of the tooth face. On the other hand, if the moments are upward-acting at the center, the chip will buckle or arch crosswise and relieve the lateral pressure originally present. The arching can develop only with the tooth face as one agency, but once the arch has formed, the effect of chip compression produced in cutting on the frictional resistance during ejection will be replaced by such minor pressure as the arch may produce in tending to flatten out.

Measurement of Lateral Pressure Effects: A test series was run to measure the effects of the trenching type of cut, in which the cutting tool is flanked on both sides by the material being cut. The test material was dry northern white pine *(Pinus strobus)* of 0.396 specific gravity, and the cutting tools were individual, inserted saw teeth. The cutting program was designed to reduce to a minimum the influence of any variation in the test block. The test block was 4.55 inches wide, 1.945 inches thick, with annual rings making an angle of 62° to 69° with the 4.55-inch side.

In the first series of test cuts, a keenly sharpened tooth 0.308 inch (7.83 millimeters) in width, with a hook angle of 50° and a back clearance angle of 1°, was used. Cuts were uniformly 0.075 inch (1.905 millimeters) in thickness. Width of cut was varied by shifting the test block laterally to engage the desired percentage of the cutting edge, thus engaging only one side of the tooth in the cutting operation. The width was varied in steps of 10, 20, 33⅓, 50, 66⅔, 80, 90, and 100 percent of full width. The 100 percent, or full-width cuts, included the "open-side" type of cut, but additional full-width cuts of the normal double-wall type were made. Open-side cuts with the left side of the tooth engaged were balanced by a like series with the right side of the tooth engaged. The test results are shown in Fig. 8.

Solid line A (Fig. 8) represents the total energy consumption for 75-mil (1.905 millimeters) cuts for all cutting widths (in percentage of total width) where one side of the cut was open. This curve begins as a straight line through the origin and remains

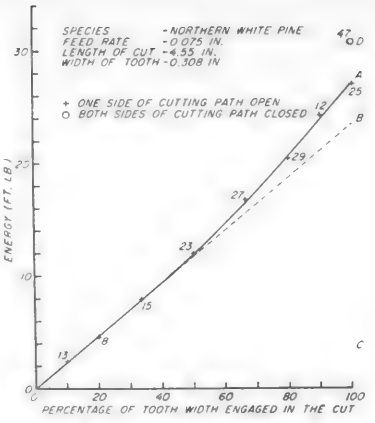

Fig. 8.—Lateral pressure effects in a trenching type of cut. (See text)

straight until the 45 percent value for width is reached. At approximately this value, the graph begins to deviate upward from broken line B, a continuation of the original direction, and reaches a value of 27.0 foot-pounds, or 3.4 foot-pounds greater than the original graph direction would indicate. This deviation may be considered as a single side or lateral effect, in this instance amounting to 12.6 percent of the straight graph, inclusive of fiber severance energy, or 14.7 percent with fiber severance energy excluded. Fiber severance energy, included in A, is shown by the dotted straight line C through the origin, based on the sharpness-calibrating tests at 100 percent width and the presumption that fiber severance energy decreases in direct proportion to the percentage of edge engaged in the wood.

The 45 percent engagement of the edge at the end of the straight portion of curve A represents an actual length of 0.139 inch (3.52 millimeters). The outer edge of the chip is free of restraint, and the chip may deform (shorten) in the direction of cutting and widen laterally towards the outer edge, which tends to lift the outer corner of the chip fragment. Such lifting of the outside edge would cause a cleavage action at the inner edge of the chip instead of a true shearing action. As the width of cut increases, the moment arm from the outer to the inner edge increases with no increase in lift, thereby reducing the cleavage force. The lateral stiffness of the chip begins to limit deformation toward the outer edge so that pressure of deformation begins to build up toward the inner edge. As the width of cutting edge increases, these factors cause a transition from cleavage to true shear at the inner edge of the chip. Since the resistance of wood to shear is much greater than its cleavage resistance, the transition from cleavage to shear increases the energy requirement for wider cuts. The upper limit of the transition zone apparently was not reached in the tests represented by Fig. 8, since the deviation of curve A from B has not yet reached a maximum even at the 100 percent width (0.308 inch). Curve A should become parallel to B at the upper limit of the transition zone if the premise is correct.

The relation between energy consumption and width of chip when only one edge of the chip must be detached during the cutting has been indicated. When both edges of the chip must be detached, the width of cut cannot be varied with the same cutting edge except by grinding the tool to successively narrower widths. Full-width cuts of groove type can be made, however, with the tooth detaching both edges of the chip from kerf walls. The energy required in making such cuts is shown by the point D (Fig. 8.). The increase in energy consumption over that used for a full-width cut with one open side (curve A at 100 percent width) is practically equal to the difference between curves A and B, but this relationship is not consistent between different samples of the same species.

A highly consistent relationship does occur, however, between the energy consumption for a cut enclosed on both sides and for one with both sides open. After deducting the fiber severance or sharpness value (the ordinate at zero feed), the energy required by the open cut is 70 = 3 percent of that required for the fully enclosed cut in northern white pine. Furthermore, the fiber severance or sharpness value obtained with fully enclosed cuts is duplicated when cuts of the same width are made with both sides open (thickness of test block exactly equal to tool width).

The energy curves for fully enclosed cuts and for cuts with both sides open, made with the same tool and material as above, are shown in Fig. 9. The zone E_f is the fiber severance energy, and the additional energy for chip crumbling and acceleration for an open-sided cut is shown as zone E_c. Fully enclosing the cut between kerf walls requires the energy for side shear, side pressure, and friction as represented by zone E_s.

When this division of energy is known for any one tool width W and chip thickness t, the total energy E for any other tool width W^1 and chip thickness t^1 may be computed by the formula

$$E^1 = \frac{t^1}{t}\left(E_s + \frac{W^1}{W}E_c\right) + \frac{W^1}{W}E_f$$

This formula should not be applied for large changes in tool width W, because of the curvilinear function indicated by Fig. 8. It is suitable for adjusting results from tools of slightly different widths to a common basis or to a standard width when the individual tool widths deviate slightly from the standard.

Effect of Grain Direction on Lateral Pressure: The variable relationship between open or fully enclosed cuts and cuts with one side open apparently results from differences in the direction of the grain. In a given test block, the difference between the open cut and the one-side-open cut may be large when the left side is open and low when the right side is open, or vice versa. When the direction of grain from the bottom (or new) surface of the chip to the top surface slopes toward the open side of the cut, the difference in energy is small. When the grain direction slopes into the closed side, however, the energy difference is high. This suggests that the chip failure along the sides is by cleavage when the grain runs out and by shear when the grain runs in.

The influence of longitudinal grain direction suggests that it would be strongly advisable to prepare test blocks for investigating lateral pressure by splitting the block from straight-grained material and dressing the sides and edges parallel to the split surfaces. The same procedure may be desirable for standard tests, especially if chip thicknesses that are more than one-third of tooth width are to be included in the tests.

Energy in the Sawdust

A certain amount of energy is represented in the velocity of sawdust as it emerges from the cut (7). This energy is readily calculated if the density of the material and its ejection velocity are known. The ejection velocity cannot be other than the velocity of the saw, since the sawdust is carried in an enclosed space bounded by the kerf walls, kerf bottom, and gullet edges. The one exception, as far as ejection velocity from a saw is concerned, is at the extreme end of the cut by each tooth, when part of the gullet extends beyond the material while the tooth is cutting the last few millimeters of wood. During this very short period, the gullet may discharge nough of its load—although this is uestionable—or be empty enough to rovide unrestricted space for movement of the last few chip particles eing cut. These final particles may lso be directed into the open air with ttle contact with kerf walls or gullet lges. The ejection velocity of these last few particles thus may not be that of the saw.

Photographs made by Chardin 2 of sawdust at the instant of ejection, and shadowgraphs of sawing action made by Thunell (8, 9) seem to indicate that the initial velocity of sawdust particles may exceed the saw speed, in which case the ejection velocity may not be a full and complete measure of the kinetic energy in sawdust at the instant of formation.

Knowledge of the ejection energy of sawdust may be useful in designing an automatic control or in the selection of saw speeds and motor sizes for a sawmill. Knowledge of the initial kinetic energy, which may differ in either direction from the ejection energy, is valuable as a part of the fundamental knowledge of cutting actions but may be difficult to obtain. Photography at high repetition rates may be the best solution. The extent of blurring during a known short interval has been used. A double exposure method using two rapid flashes of about 1-microsecond duration with an interval of 5 or 10 microseconds between them would provide sharper definition of the change in particle position, while directing the second flash at an angle of 90° from the first would provide identification (by shadow) of the first and second position of a particle. Such methods require photographing through windows in the kerf walls or immediately after ejection.

Although photography offers some opportunity to measure sawdust velocity, the job is made difficult by the inaccessibility of the sawdust space during sawing. In consequence, much reliance may have to be placed on analytical reasoning.

It is obvious, of course, that particle velocities considerably greater or less than saw velocities cannot be sustained long because the short distance from the cutting edge to the gullet edge, kerf bottom, or sawdust accumulated in the gullet would be traversed quickly, and an accelerating or decelerating contact would occur. Particles escaping from the gullet to the clearance space between the blade and kerf walls undoubtedly would be decelerated because of the high friction of the static kerf wall rather than being accelerated by the low frictional contact with the moving blade.

For the majority of the sawdust particles—those that remain in the gullet—particle velocity may be referred either to the material being sawed or to the cutting tool. The velocities of points between the rim and the center of circular saws vary directly with their radii, whereas all portions of a sawband have the same

Fig. 9.—The fiber severance energy, or sharpness value, is the same for a given width of cutting edge, whether the sides of the cut are fully enclosed or fully open.

velocity, and no centrifugal forces are involved within the cutting zone. For simplicity, then, only the action of a swaged-tooth bandsaw will be considered in detail.

At the instant of cutting, the portion of the fiber in contact with the cutting edge must accelerate to a velocity approaching that of the tool within the space and time required to create the stresses that result in severance of the fiber. The reaction forces necessary are provided by the inertia and deformation of the wood at and ahead of the cutting edge. The time interval is extremely short. The variable-angle knife tests showed that fiber severance with small wedge angles resulted from a penetration of as little as 0.01 inch. At a cutting-edge velocity of 10,000 feet per minute (2,000 inches per second), this amount of pentration occurs in 5 micro-seconds. At the larger saw-tooth angles in common use, greater penertation is required for severance, and the time interval is increased to 10 to 20 microseconds.

Concurrently with fiber severance, side shear begins at the forward end of the chip. It may progress to the rear end of the chip in a few microseconds if the direction of shearing is in the cutting direction, as would be the case with very thick chips. With thin chips, the shear strength parallel to the fiber direction may be less than the cutting force component in that direction, resulting in shearing before the face of the tooth reaches the rear end of the chip. The instant that side shear is complete marks the end of the cutting and chip-forming phase that began as the cutting edge made contact with the fibers.

Fig. 10.—The path taken by a sawdust particle during bandsaw ripping, which shows the composite motion due to movement within the sawtooth gullet and to movement of the gullet. Relative velocity is represented by the distance between the numbered points along the particle path curve, each interval corresponding to a uniform interval of time.

In the chip-forming phase, feed speed can be ignored and the velocity of the wood can be considered as zero except for those micromasses directly under the cutting edge. On the side of the cutting path next to the top of the tooth, the kinetic energy stored in the micromasses, minus internal frictional heat, is released by restoring the micromasses of fiber to approximately their original position. On the tooth-face side of the cutting path, the kinetic energy (minus heat conversion) may be expended in relieving compression when severance is completed or in assisting the side-shearing operation.

The completion of the chip-forming phase is the beginning of the chip-removal phase, but both phases occur simultaneously as a traveling phenomenon, except at the instant of starting and ending of the cut.

In the chip-removal phase, chip motion varies in direction and velocity, depending on the tooth form, chip thickness, and character of the wood. Several situations occur. First, it will be assumed that the saw has a velocity of 10,000 feet per minute. The chip thickness and wood character are also assumed to be such that the chip forms a ribbon free of cross breaks, or one in which the cross breaks are sufficiently fibrous to hold the pieces together, as in Fig. 9 of (6).

As soon as the chip is released at the sides, it is free to move under the influence of contact with a moving body, such as the tooth face or gullet edge. Since the tooth face is in contact with the chip at the time it is released, the initial motion of the chip is controlled by the tooth face. If the chip forms a continuous ribbon, as assumed, subsequent motion is controlled by the edge of the gullet and later by the bottom of the kerf.

If the chip could be cut by a flat knife of zero thickness moving at normal sawing speed, the resulting chip would be a stationary straight ribbon resistant to lengthwise compression when supported against buckling. Since any actual knife has thickness, the chip and the parent stock are separated by the insertion of the knife, and the chip slides along the face of the tool. Inasmuch as a saw tooth has no chip exit except the opening between it and the preceding tooth, which is closed off by the material during the cutting, the chip must slide along the tooth face and continue along the gullet edge. The chip ribbon is subjected to friction from the edge of the gullet and from the kerf walls, but the resulting compressive force exerted on the chip ribbon is too small to make any appreciable change in length. The chip ribbon must, then, slide over the tooth face and gullet edge at a speed equal to the cutting speed, assumed to be 10,000 feet per minute.

The path of the chip in relation to the gullet edge it follows is easily visualized by making the tool stationary and moving the material steadily upward at cutting speed. The chip velocity with respect to the gullet edge must be uniform, otherwise the chip would buckle if a leading portion slowed or the chip ribbon would separate into short sections if the leading portion accelerated.

But the path and velocity of a single chip particle in relation to the parent stock is somewhat more difficult to visualize. Fig. 10A shows the course and speed of a single particle from the moment of detachment until completion of the circuit around the gullet. The cutting line is marked off in uniform increments representing both time and length of cut or chip, and identified as t_0, t_1, . . . The tooth and gullet at the start of the cut (at time t_0) are shown by the solid-line outline divided into intervals S_0 to S_1, S_1 to S_2, . . . that are equal in length to periods t_0 to t_1, t_1 to t_2, and so forth. The broken-line outlines represent the saw position at suceeding times t_1 and t_2. The points P along the particle path curve show the particle position at those times corresponding to the same subscript number. To avoid confusion, only the lower *P* and *t* points of like subscript are connected by fine lines to facilitate visual comparison of the lengths of particle path and chip length in any increment of time Δt. Since the time interval is the same for both, the lengths are proportional to speed.

The particle traced in Fig. 10A is the foremost particle of the chip, at t_0. As the cut proceeds, the tooth face slides along the particle and pushes it to the left, since downward motion is prevented by the particles being added below it to form the chip ribbon. At t_1, the chip length t_0 to t_1 is equal to S_0 to S_1, placing the foremost particle at S_1 relative to the saw. But during the interval t_0 to t_1, S_1 has moved downward to P_1, which is the position of the foremost particle relative to the stock being cut. The length P_1 to t_1 is, of course, the same as S_0 to S_1 and is equal to the chip length t_0 to t_1. Thus, the movement of the foremost particle is from t_0 to P_1 during the interval t_0 to t_1, and the direection, distance, and mean velocity can be obtained.

Similarly at t_2, chip length t_0 to t_2 is equal to S_0 to S_2, placing the foremost particle at S_2, which has moved downward from P_1 to P_2 during the interval.

Additional points P_3 to P_{10} are similarly located to define the path of the foremost particle relative to the stock. At P_{10}, the particle is immobilized against the kerf bottom until at $t_{13.6}$ the cutting edge is again level with the foremost particle but with a thickness of chip intervening between them to form the beginning of a second layer of chip.

The second circuit of the gullet forms another turn of a spiral, much as in spooling a ribbon or rolling up a carpet, but with one important difference. In a spooling or rolling operation, the outside diameter increases by double the thickness of material for each turn. The outer turn of the spiral formed by the chip ribbon, however has a dimension fixed by the gullet and successive turns can be added to the outside only by reducing the size of all inner turns. Since the inner turns are of decreasing length, the difference in length requires each inner turn to slide against its neighboring outer turn. If the chip ribbon is continuous and smooth, the friction between turns may not prevent the required sliding. On the other hand, if the ribbon is made up of segments held loosely in place by partially detached fibers, some chip segments may

be out of line (in the cut surface) and interlock with out-of-line segments in the adjacent layers. Interlocking that prevents sliding will then cause buckling of the chip ribbon, and the spiral pattern would collapse under the frictional drag against the kerf walls.

The action of the chip ribbon has been oversimplified to avoid complication by unknown values of friction. The actual values of friction are of no importance to chip movement along the gullet edge from P_0 to P_5, Fig. 10A, during which the drag of friction tends to hold the chip ribbon against the gullet edge. From P_5 to P_{10}, however, it is principally momentum that keeps the chip against the gullet edge, assisted by any slight elasticity that may exist seeking to straighten the curved ribbon. Friction between the kerf walls and the sides of the chips exerts a force acting upward, and when the direction of the resultant of momentum and frictional force lies between the gullet edge and the vertical, the chip will lag behind the gullet edge. The force relation may be considered also as an equating of the vertical downward-acting component of momentum against the upward-acting friction force. If the friction force is great enough to reduce the vertical velocity of the chip to less than saw speed, the gullet edge will draw ahead of the sawdust and the chip movement will take a more horizontal path, as in the solid line of Fig. 10B, in which the dotted line is a repetition of the lower end of Fig. 10A. The exact shape of the curve after the chip loses contact with the gullet edge depends on the coefficient of friction of the wood being sawed and on the ratio of the mass of the chip to the combined areas of the two side edges of the chip. With its greater mass, it is obvious that a wide chip will decelerate from friction forces less than a narrow chip of the same thickness.

The horizontal components of momentum and friction also are in opposition to each other, and the friction tends to retard the horizontal movement of the chip in relation to the parent stock, even though the velocity of all points on the chip ribbon remains constant in relation to the gullet edge.[7]

The net result of blade movement, chip flow, and friction is to lay the chip ribbon against the kerf bottom in a curving path in much the same way that a cable approaches the ground as it unwinds from a spool being carried on a moving dolly or truck; the ground corresponding to the bottom of the kerf, the dolly or truck to the moving saw blade, and the cable coming from the spool corresponding to the flowing chip ribbon.

It may so happen that flow momentum will not carry the chip all the way across the gullet to the bottom of the kerf. In such conditions, the chip ribbon or particles will line up parallel to the cutting direction (Fig. 11), but at a distance from the kerf bottom that depends on gullet shape and dimensions and the momentum and frictional forces acting on the chip.

As the downward-moving gullet reaches the upper end of the stationary vertical part A of the chip ribbon, the ribbon end will be deflected at B by the motion of the newly cut portion of the chip and turned in the direction of chip flow to start the second turn of spiral. Such action occurs only when the resistance of the stationary vertical portion A is sufficient to withstand the downward impact of the new portion of the chip ribbon as the end particle accelerates in the direction and at the velocity of this new portion. The impact point B will occur somewhere in the zone of intervals t_0 to t_2 or t_3 of Fig. 10A, and the particle path direction is shown by the arrow in Fig. 11.

If the vertical portion A has inadequate resistance, the end chip may not accelerate enough or in the right direction to lie against the new part of the chip ribbon. The end particle may then take a random position and direction, the vertical portion A of the chip flow stream may buckle, and successive particles will become randomly scrambled in position against the new part of the ribbon as it overtakes them. This accumulation of particles will be held against the new portion of the chip ribbon and against each other by the downward travel of the saw and the opposing friction between the sides of the chips and the kerf walls.

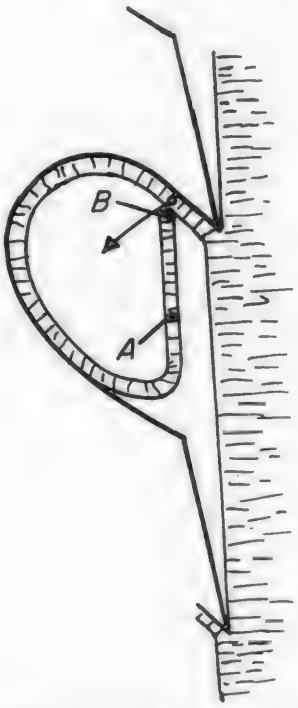

Fig. 11.—The path of a ribbon of chips in bandsaw ripping when sawdust momentum is insufficient to carry the ribbon across the forward end of the gullet into contact with the surface produced by preceding tooth.

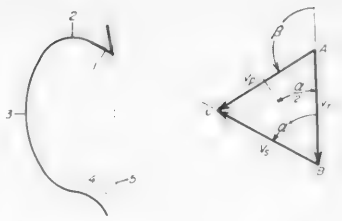

Fig. 12.—Determination of particle velocity and direction by vector diagrams at point 1 of the sawtooth gullet. (See text)

The uppermost particles in the mass will be in direct contact with the sliding chip ribbon and tend to follow with it, producing a rotary or churning action in the mass of particles.

Velocities and directions relative to the stock may be computed readily for the ribbon type of chip flow. The sliding velocity—the chip speed relative to the gullet edge—is equal to the tool velocity as previously shown. The sliding direction and velocity, and the velocity and direction of the tool (sawband) combine to determine the particle direction and velocity relative to the stock. Tool and sliding velocity are equal and constant, and tool direction is constant. Sliding direction is the only varying parameter, and thus controls the variations in the resultant velocity and direction of a chip particle at any instant.

This resultant can be obtained by drawing the appropriate vectors for any place on the tool outline at which the velocity and direction of the chip particle is to be determined, as shown in Fig. 12. For the particle at point 1, the vector A–B for tool speed and velocity is drawn in the direction of tool movement, its length representing tool velocity (V_T). The vector for sliding velocity is drawn from B to C, parallel to the tool face at point 1, and its length representing sliding velocity (V_S). The resultant, A to C, shows the direction and its length represents the velocity (V_P) of the particle at point 1, relative to the stock, ABC is an isoceles triangle, since V_S is equal to V_T, and identical right triangles are formed by bisecting

[7] This must be so, of course, as new material being added to the chip ribbon at a constant te at the cutting-edge end, and the ribbon oves around the gullet as a unit.

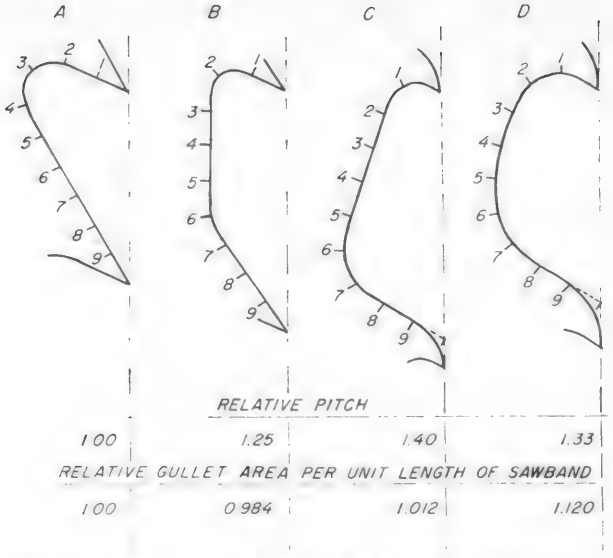

Fig. 13.—Four sawtooth designs with equal gullet perimeters (excluding the distance across the openings). The chip-removing capacity of the blade is a function of both pitch (or spacing) of the teeth and the gullet area per tooth. The effect of gullet shape on the action of sawdust is discussed in the text.

the angle a. Then $V_T \sin \frac{a}{2} = \frac{V_P}{2}$

or $V_P = 2V_T \sin \frac{a}{2}$.

The direction β of particle motion A to C is perpendicular to the bisector of a, hence

$$\beta = 90 + \frac{a}{2}$$

where both angles are measured in the same direction from the direction of tool movement.

At point 1 in Fig. 12, assuming a hook angle of 30°, a will be 60° and the particle velocity will be $2V_T \sin \frac{60°}{2}$ or $2V_T \times 0.5000$, or $1.0V_T$ in the direction $\beta = 90 + 30 = 120°$ (counterclockwise). At point 2, where the tangent to the gullet is horizontal, V_P will be $2V_T \sin \frac{90°}{2}$, or $1.414V_T$, and β will be 90 + 45 or 135°. At point 3, where the tangent to the gullet is vertical (parallel to tool direction), $V_P = 2V_T \sin \frac{180°}{2}$, or $2V_T$, and β will be 90 + 90 = 180°. At point 4, where the chip ribbon begins to turn upward, the velocity will be the same as at point 2, but β will be 225°. At point 5, where the chip ribbon is directed vertically upwards, $V_P = 2V_T \sin \frac{360°}{2}$ or $2V_T \times 0 = 0$. $\beta = 90 + 180 = 270°$, but since velocity is zero, it has no significance except as it is the limiting direction approached as the particle rounds the turn from point 4 to 5.

Particle Velocity in Relation to Gullet Design: The changes in particle velocity between a low of zero at point 5 and a high of $2V_T$ at point 3 are of particular interest from the standpoint of gullet design for best flow of a chip ribbon. The kinetic energy added to the chip is provided through the tool, but the energy subtracted from the chip may be lost through friction or may be returned to the tool by impact against the forward gullet edge. The proportions of returned energy and frictional loss may be modified by gullet shape, and these forces may be directed to promoting an easy chip flow.

For easy comparison of these forces in the four gullet shapes of Fig. 13, the length from the cutting edge around the gullet to the cutting line has been made equal for all four forms. The total transit time around this circuit will then be the same for each form of gullet for a given saw velocity. Each gullet outline is divided into ten equal parts, numbered for ready reference.

In any tooth form in which the hook angle is positive and cutting conditions are favorable to a ribbon type of chip, the chip ribbon will slide along the tooth face and be held against it by the frictional drag of the edges of the chip ribbon as the saw moves downward. At the same time, the sliding friction of the edges and one face of the chip ribbon imposes a compressive force along the length of the chip ribbon. The short segments, resulting from crosswise breaking of the chip, are kept in line and closely butted together by this compressive force, thus promoting good chip flow over the tooth face.

The straight tooth face of gullet A, extending from point 0 to point 2, provides optimum conditions for chip flow. The fillet beginning at point 2 begins to deflect the chip in a curved path, increasing the resistance to chip flow and thereby increasing the compressive force in the chip ribbon. Since the chip ribbon is an end-loaded slender column, the compressive force tends to buckle the chip ribbon. Buckling towards the tooth face is prevented by the gullet edge, of course, while buckling away from the tooth face is resisted by the frictional drag on the edges of the chip ribbon. If the fillet radius is very small, however, the turning resistance may increase the compressive force enough to cause buckling in the vicinity of point 1, despite the restraining effect of frictional drag on the ribbon edges. Also, a cross break may slip and let part of the ribbon ride over the preceding portion.

Shortening the tooth face, as in gullets B and C, shortens the slender chip column and makes it more resistant to buckling, but a reduction in fillet radius, as in B, will counteract the gain from shortening the tooth face. The most favorable conditions are obtained by combining a large fillet radius with a short tooth face, as in gullet D.

Favorable conditions for chip flow continue around the fillet to the point at which it is tangent to a line parallel to the cutting direction. This tangency point lies about midway between points 3 and 4, call it 3.5, for gullet A. At any point further along the gullet edge, the frictional drag on the chip-ribbon edges tends to make the chip lag behind the gullet edge. Once contact with the gullet edge is lost chip flow can be directed only by chip momentum and friction. For gullet A favorable conditions for chip flow exist only for the first 3.5 length-units or 35 percent of the gullet-edge length.

For gullet B, the tangency "point" becomes a straight line extending from 2.5 to 5.6. Conditions are definitely favorable to chip flow up to 2.5 length-units or 25 percent. They are less favorable between 2.5 and 5.6 because slender-column conditions prevail, with no force other than chip stiffness to prevent buckling toward the cutting line. Beyond the 5.6 point the remaining 4.4 length-units present the unfavorable conditions resulting in chip lag.

Gullet C has its tangency point at 6, indicating favorable conditions for 6 length-units or 60 percent of the gullet-edge length. The small fillet at the tooth face tends toward higher compressive force in the portion of the chip ribbon along the tooth face, but is compensated by the shortness of the tooth face. The section of the chip ribbon between 1.5 and 5.5 has a straight, slender-column configuration, but the large radius fillet from 5.5 to 7.5 will not produce high turning resistance, and the frictional drag on the ribbon edges will tend to resist buckling toward the cutting line.

Gullet D also has its tangency point at 6, giving favorable chip-flow conditions over 60 percent of the gullet edge, but conditions are more favorable than in gullet C in three respects. First, the fillet at the tooth has a greater radius, which reduces the turning resistance. Second, the edge from 2 to 6 is a gentle arc that buckles the slender-column portion of the chip ribbon against the gullet edge with additional support from frictional drag to hold the chip against the gullet edge. Third, the gentle curvature at point 6 reduces the compressive force along the chip due to turning resistance.

Other factors in addition to chip flow must be considered in sawtooth design, and will be discussed in the final portion of this article, which will appear in the November issue of the FOREST PRODUCTS JOURNAL.

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PAST PROGRESS AND FUTURE PROSPECTS OF

Insulating Board in Canada[1]

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A brief history of the establishment and development of the insulating board industry in Canada—with emphasis on the cyclical ups and downs of production and consumption—is used as a basis to forecast product development, production growth, and market prospects for the future.

IN CANADA, INSULATING BOARD IS usually made of wood fibre in densities ranging from 16 to 20 pounds per cubic foot. Common thicknesses are 7/16, ½, 5/8, and ¾ inch. Greater thicknesses are built up by lamination. There are two main types—the majority are homogeneous boards made from a single lap of pulp; the second type is made by laminating together several layers of thick paper. The latter should be differentiated from thin laminated boards which are primarily intended for wallboard rather than insulating purposes and also from hardboards, which are made from a wet lap similar to that used in homogeneous insulating board and then pressed between heated steel plates to produce a hard, dense board.

As a basis for trying to see what are the likely prospects for the future, it is worth examining the history of this industry. Insulating board has had a comparatively short history. It was manufactured on a very small scale prior to 1928, but the industry has expanded enormously from a capacity of less than 50 million square feet in 1928 to nearly 600 million square feet at the present time.

Early History

Insulating board is believed to be originated in 1882 by D. M. Sutherland, who was then associated with the production of millboards in England. In 1898, the Patent Impermeable Millboard Company Limited

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was formed. The first boards were laminated paper, but homogeneous boards were made by this company prior to 1908 and large quantities were shipped to the U.S.A. These homogeneous boards shipped from the U.K. are believed to be the first used in the U.S.A. and in North America. The tariff was then 55 percent and, as a result, manufacture was started in the U.S.A. at Trenton, N.J.

In Canada, patents were taken out in 1912 in the name of Manson, who built a pilot plant at Cornwall, Ontario. Manley Chew, a lumberman who operated in the Georgian Bay area, became interested and built a plant at Penetanguishene, Ontario, where he produced a 4- by 8-foot insulating board which was registered under the name of Ten/Test. In 1923, Chew sold his interest to a company known as International Fiberboard Company Limited. The Penetanguishene plant burnt out in April, 1923 and was rebuilt at Midland, Ontario on the property of the Georgian Bay Shook Mills. This plant was again destroyed by fire and rebuilt. In 1927, the company was purchased by Canadian International Paper Company, and a mill was built at Gatineau, Quebec. In 1926, Building Products was founded, and a mill was built by Donnacona Paper Company in 1930. The period up to 1926 or 1927 can be regarded as the experimental period, after which the big names in the paper and building materials industry become associated with insulating board. Up to this point, insulating board had been regarded as a homogeneous material. The laminated boards, such as Beaver board which was first made in 1916, were thinner and used for different purposes. Building Products, however, introduced an insulating board made by a laminating process and both homogeneous and laminated boards were then used in building insulation.

The Depression Years

The period between 1926 and the depression saw the start of large-scale manufacture, and by 1930 there were three mills with a capacity of 40 to 50 million square feet per year on ½-inch thick basis.

This was a terrible time for the young industry; had it not been for the export market, which was open to it from 1926 to 1936, it is doubtful if it could have survived. During these early years, the industry was active in selling the value of insulation in buildings and there was little competition in this field from other materials. Much publicity was given by Government and other official sources, and the industry generally did a good job of educating architects and builders on fuel savings and increased comfort resulting from better insulation. The success achieved can be appreciated by relating it to the rate of building construction, which started a great decline in the second quarter of 1928 from $373 million to an all-time low of $59 million in 1933 and showed little sign of recovery until the second quarter of 1935. During this period, domestic shipments of fiberboard increased from 16 million to 29 million square feet. This indicated that a rapidly-increasing quantity of fiberboard was being used per housing unit or per dollar value of construction. Exports in 1935 exceeded domestic shipments, and continued progress was made during the remaining 1930's. In spite of this improvement, the outlook in 1939 was not good. In 1930, capacity was 130 million feet, but domestic shipments of 31 million and export shipments of 15 million added up to a total of 46 million square feet or about 35 percent of capacity. In 1939, capacity had risen to 146 million square feet. Domestic shipments were 52 million and export shipments 41 million square feet, a total of 93 million, still only 64 percent of capacity. It will be seen, therefore, that the Canadian Industry had expanded too fast for domestic needs, and export shipments had not continued their expansion. In fact, export prospects began to decline as additional European mills came into operation.

The War Years

Sales problems were lifted from the industry by the war, which was a period of full production. The requirements for the armed services, wartime housing, and defense industries left little available for normal domestic requirements. Distribution was controlled to a large extent by a Government administrator, and much of the production that would normally have gone into the domestic market was shipped overseas to the various theatres of war. The war years did, however, give an impetus to demand by popularizing the use of insulating board.

The wartime consumption of insulating board in Canada rose from 51½ million square feet in 1939 to 98 million in 1945. This, with the overseas wartime requirements, represented the industry's entire productive capacity at that time.

Post-War Expansion

In 1945, for the first time the future justified a spirit of optimism. The domestic market with its backlog of housing requirements from the war period lay ahead. This was so large that the industry could face the loss of the traditional export markets without too much concern. (The U.K. market, which had always consumed the greatest volume, disappeared because of sterling restrictions.)

The industry again began to expand and modernize. Moulding in single panels, which was the general method of manufacture in Canada up to this time, was replaced in the major mills by forming on continuous cylinder or fourdrinier machines. For 10 years, the industry ran at capacity; during most of these years imports exceeded exports, and from 1949 until 1955 domestic consumption was generally in excess of Canadian capacity.

In 1946, the demand for special primed and painted boards made it necessary to produce boards with surfaces capable of taking smooth finishes, which involved capital investment for improvements, such as suction presses which had previously been proved in the United States. Up to 1946, mills adhered closely to Government standards, and they were satisfied to reach this quality. Producers soon began to go far beyond these standards, however, particularly in strength. They achieved this in spite of having to use less desirable species of wood. Prior to the war, Canadian insulating board mills were often integrated with newsprint mills for their wood supply, and they were able to get ample quantities of jack pine which was not then much used for newsprint. Since then the position has changed, and the insulating board mills are making improved products from woods that they would have considered unsuitable in pre-war days.

In 1955, for the first time since the 1930's, productive capacity exceeded domestic consumption. This was followed by a good year in 1956 postponing the return of hard times until 1957. In 1957 and 1958, some major new plants were opened which added to capacity, In particular, the Johns-Manville organization opened a new, modern plant at North Bay which set new standards of quality in certain products.

Future Prospects

This history of the past 30 years has been characterized by abrupt changes from over-capacity to under-capacity and back again. It is difficult, therefore, to find a basis for estimating future prospects. The years since 1946 have also seen big changes in the types of product made, which makes it difficult to estimate future consumption by uses.

The main types of products made in 1959 compared with 1946 are as follows:

Product	1946 %	1959 %
Panels	63	19
Roof board	13	39
Sheathing	*	23
Plaster Base	11	1
Decorative	)	17
Other	) 13	1

*Included in panels.

These percentages are only approximate because there have been changes in classification of figures supplied to the Dominion Bureau of Statistics, but they show that there has been a marked decline in the amount of board sold as standard panels. Sheathing was introduced in 1943 and was still in the early stages of development in 1946. The loss of almost all the plaster base market and the reduction in standard panels reflects the fact that insulating board has been displaced as the internal lining on walls of housing, but has made good this loss by securing a large share of the exterior lining as sheathing. Other applications for panels have been taken over by the decorative products. Acoustic tiles, which are in this classification, have become increasingly important. The continued development of new styles in these tiles and in plain ceiling tiles has kept a good share of the market in spite of competition from other materials.

When the prospects for insulating board are considered from the point of view of product development, it is typical that first a use such as insulation is developed and then other cheaper or more efficient materials come into the field and take an increasing share of this business. Meanwhile, new applications are developed for insulating board and these, in turn, are attacked by competition.

At the present time, insulating board sheathing appears to be holding its own. Although roof board is responsible for an increasing share of total sales, there are grounds for concern because other light-weight materials are considerably more efficient insulators, and they can be supplied at a lower cost per unit of insulation value. So far, difficulties in making these materials strong enough or protecting them from traffic on a roof has slowed down their progress, but they can offer advantages in ease of handling, freight savings, and moisture resistance so that roof board, which is the biggest single application of insulating board, is likely to face increased competition.

New Products

What new products has the industry under development to maintain its progress in spite of losses in some applications? If we examine the physical properties of insulating board one by one, we will find in each case that there is probably some other material with a better test figure. Insulating board, however, combines a number of reasonably good properties at low cost and successful new products should exploit these multiple properties. For example, insulating board has fairly high moisture absorption. At first sight, this is a disadvantage because any increase in moisture content decreases the thermal insulation of a material since conductivity is directly proportional to density. Tests show, however, that a 10 percent increase in moisture content, which is the increase that results from exposing homogeneous insulating board to saturated air for long periods, reduces the thermal resistance by less than 4 percent. It is concluded that this is due to the water being absorbed by the fibres which has less effect on insulation than water accumulating in the interstices, which would be the case with a granular material. This ability to absorb and evaporate moisture probably accounts for insulating board standing up under severe moisture conditions that theoretically should cause failure. This shows that insulating board has good all-round properties suited to the wide range of building conditions met with in this climate.

Many of our product development ideas come from the United States. The roof-deck slab, for example, is being successfully used for open-beam ceiling construction in the States. These slabs consist of insulating board, 2 feet wide by 8 feet long, laminated to thickness of 1½ inches or more, according to the insulation and spans required. This is a good example of a product which makes use of the all-round properties of insulating board. It makes use of insulation, structural strength, and the ability to provide decorative finishes on the underside and incorporate a vapour barrier. Unfortunately, it has not made much headway in Canada, but it deserves more emphasis.

One field of application which could well receive more attention is in acoustic insulation. As homes become more and more compact and better equipped with television, radio, and hi–fi (not to mention the increased interest in musical instruments) acoustic insulation is becoming more of a necessity. Resistance to airborne sound depends primarily on mass, which is not provided in the modern light-weight materials. In prefabricated housing, a partition with a core of insulating board faced with decorative sheet materials could be made 1 to 2 inches thick at a weight of 3 to 5 pounds per square foot, which would give a fair degree of sound insulation. There are also methods of improving sound insulation in partition walls of traditional housing. The difficulty in selling this is that sound insulation, or the lack of it, does not show when a house is bought and people are not willing to pay extra for what they cannot see.

Future Markets

During the past 10 years, consumption of insulating board has increased at an average rate of over 6 per cent per year, which is a little better than the average yearly increase in the value of all building construction (expressed in constant dollars). If the consumption trend is projected, it will not catch up with capacity until 1964. The capacity figure of 600 million square feet per year is misleading, however, because it does not take account of the product mix which has changed considerably. The industry is, therefore, nearer to capacity operation than the figures quoted indicate, but additional facilities to make the products in demand are being added.

For long-term estimates, it must be recognized that the industry has gone beyond the early stage of rapid growth and the curve of progress has flattened out. It is reasonable to assume that the industry will continue to get its present share of the building dollar, which means that the market will expand by 4 to 5 per cent per year. To do this, however, it will have to make considerable efforts in product development, because the position of the present lines of products is not static. The conclusion is, therefore, that the industry should be able to maintain its position, but this will only be achieved by a lot of hard work.

Standards and Test Methods for Particle Boards[1]

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PARTICLE BOARDS HAVE BEEN ACCEPTED on the market so quickly that the development of proper testing methods has remained behind the development of the industrial process technique. This explains why systematic work on testing methods has just started in recent years. At the beginning of the manufacture of particle board, the improvements in the technique followed one another so quickly that there was no demand for special testing methods. The existing testing methods for fiberboard were sufficient 'till the early fifties.

This situation changed when more and more competitive products appeared on the market. The different kinds of particle board became more similar. The smaller the remaining differences became in terms of quality of products, the more difficult it became to prove them objectively. Today, the particle board industry needs testing methods of refined sensitivity and discriminative sharpness that will make possible the determination of small differences with sufficient accuracy.

A large flakeboard plant based on the Novopan process started the industrial development of particle board in Switzerland in 1945. One Novopan plant and several Behr plants followed in Germany, in the early fifties. The more recent developments, all of them should not be recalled here, are the windsifting method of Bähre and the extrusion process of Kreibaum. The Bartrev process initiated the first continuous particle board press in Great Britain.

The development of particle board is progressing throughout the world. The first European Standard (BS #1811) regulating the testing methods was published in England in 1952. The German Standards DIN #52360 through DIN 52363 followed in 1955. Nearly all countries have now started to work on standards.

Economic development forces standardization. There are groups of manufacturers of particle board in industrial countries who are very much concerned with the steady improvement of their particle boards and who spare no cost to keep the complicated production processes under control. Such particle boards are often confronted with other ones manufactured with substantially less care. The quality plants find themselves frequently in a defensive position because the particle board consumer does not have the means to check objectively the difference in quality. The quality plants try to protect their slice of the market by using legally protected quality assurance signs or through organizations protecting the quality level. Establishing and supervising quality rules require dependable testing methods. Economics was the true cause of systematic studies of testing methods. This itself indeed is a healthy development, but it should not mislead to a hasty standardization without scientific foundation.

For now, standards for quality requirements can only list evaluating properties tested in plant control. Since most application properties can be correlated with basic properties, standards should be established without further delay.

The level of technical quality demonstrates a broad similarity in the different countries. The fact that many particle board plants have been designed and built by the same engineers who have installed the same or similar equipment partially explains this similarity. The very successful activities of the European Particle Board Association (FESYP) demonstrates that the European particle board industry is ready for broad cooperation with regard to testing and quality-requirement standards. The timing for international standardization is excellent. With the single exception of the British Standard, all important standards exist as drafts only, and can be easily adjusted to conform with each other. It will definitely be too late to undertake this task some years from now.

Fundamentally, one has to distinguish between methods for control of production and methods for evaluating properties that influence the techques of application. The methods for control have been much further developed than the methods for evaluating the properties influencing the application technique. This is the result of developmental work done by the particle board and machine industries, which were interested primarily in production control. All of the European research institutes are studying the somewhat neglected testing methods for properties influencing the application technique.

The Testing Methods for Plant Control

The objective of plant control is to uncover all shortcomings at the moment they develop, and to correct them. The present level of testing does not permit us to fulfill this objective with some types of shortcomings. Among the variables determining the properties of particle board, the moisture content, the resin content, and the degree of polymerization of the synthetic resin are difficult to measure. There is no lack of suitable methods, but their application requires too much time.

For exact determination of moisture content, only the oven-drying method is acceptable, which in turn requires about 15 minutes with infrared-heated drying balances. Measuring electrical resistance produces an immediate answer, but wood chemicals and electrolytes of the hardener easily cause a false reading.

On the other hand, the reaction of the dryer to its control setting is dependent upon the design of the dryer and is more or less delayed. Relatively large amounts of particles are introduced to the process before a drying error is completely eliminated.

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The only relatively reliable method of control of the synthetic resin content is through the estimation of nitrogen content, by the method of Kjeldahl. The long time required to ash the sample completely when microanalysis is used makes this method unsuitable for production control. The degree of polymerization achieved by pressing is most difficult to estimate. In this regard, experiments on water-soaked samples give some information that cannot always be successfully interpreted.

Therefore, in most instances, the production personnel are still in charge of the supervision of the machine equipment. Because the production process cannot be kept under control in all of its stages, the properties of the finished product show some variation. The actual plant control today based on statistical methods starts behind the press at the end of the production. It limits itself to a small number of properties such as density, bending strength, tensile strength perpendicular to surface, and swelling in thickness under water.

All known standards determine the bending strength with a centrally loaded beam on two supports. The bending strength depends functionally on the tensile strength of the surface layers, and indicates whether they have been properly manufactured. One testing standard, in addition to the testing speed, requires an indication of the size of the sample, its length, width, and length of the span. The width of the sample does not influence the bending strength and can be chosen arbitrarily. In Germany, the width of the sample is the same for all board thicknesses, 50 millimeters (or 1.969 inches).

The span requires some consideration, also. Smaller spans result in large sheer stresses developing in the center layer of the sample. Most of the testing standards define the span as a multiple of the thickness of the sample. For example, the AFnor Pr B 51–120 requires 15 times the thickness, the DIN 52 362 (Edition 1955) requires 20 times the thickness. The idea being to completely eliminate the influence of the shearing stresses. German investigations have proved, however, that with a good particle board the "critical" span at which significant shearing stresses would develop is much shorter than anticipated, only 5 to 8 times the thickness of the sample.

Progressive reduction of the span length first causes an increase in the bending strength values, and only the very short samples show a significant decline in the averages of the bending strength. It is probable that the span required by the German Standard will be reduced in the future. If an influence of the shear stresses became evident it would even be desirable. It would point out gluing defects in the middle layer, which otherwise only the tensile test perpendicular to the surface would discover. By shortening the span, the test of the bending strength, which itself requires least effort in all standards, will increase its value for the control. However, the use of the same size of samples over larger range of thicknesses, up to 25 millimeters (63/64 inch) similar as in British Standard BS 1811 is permissible. The span is then 150 millimeters (5.91 inches) the width of the sample is 50 millimeters (1.99 inches) and its length is 200 millimeters (7.90 inches).

Using a relatively longer span with thin particle board than with a thick one for all practical purposes does not have any significance, because the defects in the center layer are more frequent with a thick board. The additional methods of estimation of the modulus of elasticity described in most of the European Standards are rather too primitive. This testing method should follow the example of the American Standard for plywood ASTM D 805. The control of the modulus of elasticity is of no importance for the plant control.

Importance of Tensile Strength Perpendicular to the Surface

Tensile strength perpendicular to the surface is one of the most revealing properties of particle board. Its testing can not be overlooked in any plant. It indicates the gluing defects in the middle layer. When the hardening process of the synthetic resin is delayed too long under certain circumstances, some of the glue bonds in the middle layer can break under the spring-back stress of the densified particle mat when the press opens. Too high a moisture content of the middle layer, too short a pressing cycle, too low a platen temperature, or erroneous addition of hardener cause such defects. These are hidden defects that can be detected only in the much advanced stage as open splits.

The tendency to shorten the pressing cycle is spreading through the particle board industry, and considerably increases the danger of gluing defects. Many plants are working without any safety margin.

To test the tensile strength perpendicular to the surface, samples 50 millimeters (1.969 inches) square have been used in Europe. The samples are glued between wooden or metallic blocks and broken in a testing machine. The gripping heads have to be suspended on kardan joints. The samples for this test are highly susceptible to proper, out-of-center alignment, and have to be carefully prepared. The tensile-perpendicular-to-surface test requires a rather large amount of work. The use of metallic blocks pays off only when the testing is occasional. Cleaning the metal blocks for a large number of samples requires too much work, and therefore the use of disposable blocks cut from hardwood or plywood is more economical.

The results of the cleavage tests are in correlation with the values obtained from tensile tests perpendicular to the surface, and can replace the latter for the purpose of plant control. The cleavage test is not suitable for comparison of different products and therefore is not provided for in the Standards.

The changes of form caused by moisture absorption are generally determined after a specified period of immersion in water. Some standards also provide for exposure of samples to moist air. These methods require extended periods of time and therefore are not suitable for plant control. With the extruded board, the swelling in length in the direction of the extrusion is of particular interest. The swelling in planes perpendicular to the direction of the extrusion is greatly reduced by effect of crossbanding. Often, samples 100 millimeters (3.937 inches) square are used to test swelling in thickness. The increase in thickness is measured at four corners and at the center. This method is based on the corresponding standard for fiberboard, which has been mostly taken over without much consideration. The improvements in the gluing technique and the use of waterproofing additives has rendered this method obsolete. The dimensions of the sample for the soak test have to be reduced drastically in order to secure significant differences in swelling after short periods of immersion. Despite some resistance, German manufacturers finally decided on a 25 millimeter (0.984 inch) square sample. This size has also been accepted in the new edition of the Standard DIN 52 361. The quality requirements of the Standard DIN 68 761 are based on the smaller sample size. Circular samples can be used instead of square ones, and can be cut out easily to a closer tolerance.

Measuring the swelling after two different periods of immersion is recommended. For a waterproofed particle board immersed in water at 20° C (68° F), the first reliable measurement of swelling is obtained in two hours. The waterproofing agents only slow down the penetration of the water into the sample. After a sufficiently

long immersion period in water, the waterproofing materials lose their effectiveness. With present manufacturing procedures, this situation can be observed after an immersion period of 24 hours. Swelling test values, after 2 hours immersion, preferably show the efficiency of the waterproofing materials; values after a 24 hour immersion show the quality of the glue bond and also give an indication of the degree of polymerization of the synthetic resin. Thickness gauges with a reading capacity down to 1/100 millimeter (0.4 mills) are required for measuring the swelling.

The density and its distribution in the board are critical characteristics that indicate the effectiveness of the forming and metering devices. Practically, the density is calculated as weighted average from the weights of the individual samples and their volume. Since the thickness of the sample is also used for the determination of swelling, the use of the same sample for both tests is recommended. The variance of the density can be calculated from a combination of the variances of thickness and weight. With accurately cut samples, the variation of the length and width can be disregarded. The circular sample always meets this condition.

Now the question comes up whether the four described properties (bending strength, tensile strength perpendicular to surface, swelling in thickness, and the density) provide sufficient plant control or whether some other properties will have to be controlled as well in the future. According to the general experience in Germany, the four standard properties are sufficient. The bending strength permits evaluation of the quality of the surface layers and correlates well with the tensile strength parallel to the surface and with the modulus of elasticity. The glue bond of the middle layer is controlled by means of the tensile strength perpendicular to surface. It also gives a measure of cleavage strength and screwholding ability (screw pull-out parallel to the surface). The swelling in thickness indicates the efficiency of the waterproofing materials and the quality of the glue bond of the entire board. The synthetic resin content cannot be continuously controlled. Production control requires the use of the analysis for nitrogen content only occasionally when the results of the strength or swelling tests are suspicious.

Testing Methods for Application Technique Properties

While plant control can limit itself to some few properties, the number of the properties important to the application technique can hardly be reviewed. Because practically no particle board is used for outside exposure application or for load-bearing constructions, the standardization of testing methods for resistance to outside exposure, and strength and elasticity properties has been shelved. The great majority of the boards manufactured in Europe are used in furniture and interior finish, and bear thereafter only negligible static load. To select the most suitable products, in addition to workability (tool and machine requirements) specifically the stability of the form, screwholding, quality of the surface, and veneering ability are the determining properties. Yet the corresponding testing methods still are more or less problematical.

The influence of moisture content endangers the dimensional stability of wood and wood materials. Studies of this problem have been published. They followed known experimental methods. The sample of the test board is covered and attached to the top of a tank of water. The difference in vapor pressure from the saturated air under the sample and the dryer air in the room starts a diffusion stream of vapor from inside of the tank to the outside surface of the sample. The dimensional changes caused by the swelling make the board vault. The greatest distance of the top of this vault from the flat surface is the measure of the stability of the form. This experiment itself looks convincing, but is very problematical with regard to the testing technique. The very slow water diffusion often requires weeks to reach an equilibrium. Waterproofed boards require an experiment that lasts several months. To draw conclusions describing a large population requires large numbers of experiments, which in turn require large numbers of water tanks and measuring instruments that have to remain attached to the sample during the whole observation period. The experimental efforts are not in agreement with the usable amount of information. Therefore a reduction of the testing to variables that determine the form stability, the stiffness, and swelling properties seems to be justified. No experimental results proving the correlation between the two last properties and the form stability are available. At first, it can be recommended that the user of particle board select boards with high bending strength and low swelling when looking for a good form stability.

Nailholding and Screwholding Ability

Holding ability is generally determined by pull-out tests. A satisfactory method is not yet available for this test. The friction forces influence the pull-out resistance of the nail, which depends itself upon the condition of the surface of the nail. Oxidation of the surface of the nail increase friction. A trace of fat decreases this friction. Test results with commercially available nails show variation that is not entirely caused by variation of the material. Resistance to nail-pull is of little practical importance, because particle board is nailed only for very inferior purposes. There is no advantage in refining this testing method. A quite different situation exists with the screw inserted parallel to the surface. The screwholding determines the size of the mounting, hinge, and piano hinge.

The draft of the French Standard AFnor Pr B 51–123 can serve as an example for a standard for testing screwholding. The screw-pull-out test requires as much care in drilling the hole as in inserting the screw. In Germany, the screwholding test was given up after systematic experiments with large samples (for 100 individual tests on each of 28 different board types) had shown highly significant, accurate correlation of screwholding ability parallel to surface with cleavage resistance and tensile strength perpendicular to surface. The used who is looking for good screwholding ability should select boards with high tensile strength perpendicular to the surface. The explanations in the Standard DIN 68761 (Quality requirements) particularly point out this relationship.

There are two drafts of French Standards available for the testing of surface hardness: the AFnor Pr 51–121 (Durete par ma methods Monnin) and AFnor Pr 51–122 (Deformation sur charge localisee). The method of Monnin is related to the known metal testing procedures and is similar to the tests of Brinell, Vickers and Rockwell. A load of 300 kilograms (661.4 lbs) or 100 kilograms per centimeter of width (562 lbs per inch of width) impresses the compression tool, a half of a cylinder, in samples of 30 millimeters (1–3/16 inches) width and 100 millimeters (3–15/16 inches) length. The compression tool is blackened by printing ink or stamp ink in order to determine the width of the impressed part of the cylinder after the pressure is released. From the formula of the circle, the corresponding impression depth can be calculated, and the reciprocal value represents the Monnin hardness. This value is a measure of the drive-in resistance of nails. This testing method is surprisingly simple but the interpretation of the test results is rather difficult. The width of the impression of the cylinder doc

Table 1.—REVIEW OF THE MOST IMPORTANT EUROPEAN STANDARDS (QUALITY REQUIREMENTS AND TESTING METHODS)

Country	Quality requirements		Testing methods	
Germany	DIN 68 761	Draft	DIN 52 360/363 in revision	
France	CTB-P	Draft	AFnor Pr B 51-112/123	draft
England	BS 2604:1955	Final	BS 1811:1952	final
Holland	2121-60	Draft	3217-60	draft

Table 2.—DIFFERENCES BETWEEN EUROPEAN STANDARDS

Country	Standard	Defined properties
Germany	DIN 68761	Tensile strength perpendicular to surface
Great Britain	BS 2604	Impact resistance (falling weight) Remaining form changes under long-term loads Modulus of Elasticity
France	CTB-P	Tensile strength perpendicular to surface Monnin hardness Screwholding (pull-out resistance) Surface quality
Holland	2121-60	Tensile strength parallel to surface Tensile strength perpendicular to surface Screw and nail holding (pull-out resistance) parallel and perpendicular to surface Modulus of Elasticity

not depend on the hardness of the surface layer only, but also on the yielding of the middle layer as well. A large Monnin number does not indicate exclusively a very hard surface, but possibly a very soft middle layer as well. Often a correlation of the Monnin number and density has been established.

The French method to determine the resistance to a local load (AFnor Pr B 51–122) impresses a 5 centimeter (1–31/32 inch) square piece of metal 1 millimeter (0.039 inch) deep in a 100 by 100 millimeter (3–15/16 inch by 3 15/16 inch) board sample. The load required to cause this impression is measured. The remaining impression caused by this load is also measured. This testing method gives clues how a floor will behave under the load of heavy furniture, pianos, and grand pianos.

A satisfactory method to evaluate the surface quality is not available. This is the problem: Sometimes we use only face veneer without crossbanding on high quality particle boards, also when a high-gloss surface treatment is required. Occasionally, penetration of moisture from the surface as from the veneer glue line causes some thicker particles inside of the board to swell up and to show through the face. This local swelling shows up under side light as "waving" imperfections, especially in the case of the better and smoother polishes. A test method that will indicate a tendency of a board to "waving" is needed.

The task is difficult to solve because the "waving" is a rare event in a statistical sense. An arbitrary reproduction of this damage can be achieved only by chance corresponding to the law of the Poisson Distribution. First it must be assured that a closely controlled amount of water is induced to the surface. Obviously, this amount of water is adjusted to the average moisture content of the veneer glue line or to about 100 grams per square meter (20.5 lbs per 1000 sq. ft.). Then it must be made certain that this amount of water will diffuse into the board and not evaporate. Finally, it is recommended that this diffusion process be forced at elevated temperatures to approach closely the condition of veneering in a hot press. In Karlsruhe, the required amount of water is absorbed in a blotter of suitable thickness and "ironed" on the board in a heated pressing device. The profile of the local swelling that appears under the blotting paper is then measured by means of mechanical, optical, pneumatic, or electronic device and reported. The average swelling and the roughness of the surface is estimated from the profile line with the help of a planimeter. While numerous methods of the measuring techniques are available, including a very elegant French solution using a circuling Feeler, the interpretation and evaluation of the experiments creates some difficulties. Probably every one of the European research institutes is studying this problem.

A warning should be impressed not to use primitive, home-made experiments to evaluate particle board. These experiments usually consist of covering a pot of boiling water with a board sample. The condition of the exposed surface of the sample is examined after a certain time of steaming.

European Quality Requirements for Particle Boards

The content of all known particle board standards is divided into testing methods and quality requirements. Table 1 shows the designations of the most important standards.

Table 1 is not complete. While this information was being put together, the FESYP learned that the Scandinavian countries are preparing standards, whose content could now be considered for this report. England has the only final Regulation of the Quality Requirements (BS 2604) restricted to only two thicknesses, ½ and ¾ inch. The British Standard should be called to our attention as the first one that not only sets limits for average values, but also contains regulations referring to the ranges of the values. It required the British particle board manufacturer to install statistical plant control, results of which are accepted by the organization, protecting the quality level. In contrast to great Britain, all European standards are in their draft stages. The economic situation explains the somewhat hesitant attitude of the countries of the European continent. Their markets attract a large number of different particle board products, which in turn make it rather difficult to establish just quality requirements. The example of Japan exhibits that countries with fewer particle board plants can standardize more easily than countries with a very diversified supply of boards. (See JIS A 5908:1957)

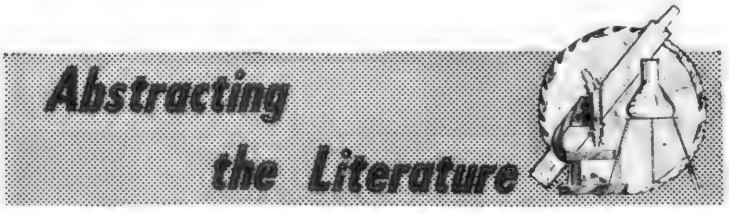
When quality requirements should be worked out, the question whether average products or top-quality products are involved is very important. Countries with keen competition, as for example France and Germany, incline to set up requirements for top-quality products, while the British Standard corresponding to the present technical level can register an average only. Most of the particle board standards apply for the density range from 450 kilograms per cubic meter (27.9 lbs per cu. ft.) to 800 kilograms per cubic meter (49.6 lbs per cu. ft.). They include in essence the boards for furniture core stock with an average density of 600 kilograms per cubic meter (37.2 lbs per cu. ft.). The present form of the draft of the German Standard DIN 68761 contains quality requirements for furniture core stock only, although provisions made will allow for future extensions. Soon, quality requirement standards for low-density particle boards (density less than 450 kilograms per cubic meter or 27.9 lbs per cu. ft.) used for thermal and accoustical insulation will follow. The draft of the German Standard DIN 68761 includes the extruded boards as well, even though their properties differ from those of flat-pressed boards. The flat-pressed boards are divided into two types. High bending strength (form stability) distinguishes the first type, and high tensile strength perpendicular to surface is the foremost property of the second type.

A feature common to all European quality regulations is the selection of three properties for evaluation: density, bending strength, and swelling caused by water absorption. In addition to this, different standards define other properties as well.

In Table 2, the draft of German DIN 68761 depends on the evaluation of four properties only, density, bending strength, tensile perpendicular to surface, and swelling in thickness. This restriction is based on statistical consideration and experience. Correlations have been found between the evaluating properties listed in Table 2. One covariable of a group of covariables is sufficient to use for evaluation.

Summary

A comparison of the European standards and standard drafts indicates that the ideas behind them are to a great extent identical. Only the testing methods of the plant control are sufficiently advanced to be regulated by a final standard. Before any properties influencing the technical application can be defined, tested, and standardized, many problems still not solved have to be worked out. For the time being, the standard of quality requirements can list only the evaluating properties that belong by their nature to the plant control. It must be investigated whether a restriction of the control properties only would not possibly lead to the technical development of the particle board industry in an undesirable direction. Using somewhat different words, this question could be formulated as to whether an increase in value of the properties presently used for evaluation of the board always increases its practical use value. Most of the properties important for technical application could be correlated by means of known statistical methods with one or more of the standard properties. There is, therefore, no valid argument suggesting a further delay of the work on the standards.



MECHANICAL PULPING

Fields, W. F. (Armstrong Cork Co.) Recent improvements in pulpwood grinders for insulating fiberboard manufacture. Tappi 43, no. 4: 202–7A (April, 1960).

A study was made to det. if design improvements could be made to improve the efficiency of the grinders and/or improve pulp uniformity in an installation for the mech. pulping of loblolly pine. Objectives of the study were: to det. if the surface speed could be increased, and if so, to det. the max. allowable speed; to increase the speed of the pressure foot during nonproductive portions of the grinder cycle retraction and advancing wood to the stone surface); and to control the pressure foot with regard to B-680—Forest Products Gal. 67 feed rates to keep a const. relationship between feed and speed without regard to the resulting variability in hydraulic pressures or motor loading. To accomplish the second and third objectives, it was decided to go to a high pressure hydraulic system so that a small, low-vol., fast-acting cylinder could be used to actuate the pressure foot. A 50% increase in capacity was effected, which is partly the result of a redn. in reaction time and partly an increase in the grinding rate. The hydraulic control circuit design is outlined in an appendix. 5 ref. (A.B.I.P.C. 30:12)

CHARCOAL

Ward, J. C., and Lane, P. H. Water sprays will shorten charcoal cooling time. U.S. Forest Serv., Lakes State Forest Expt. Sta., Tech. Notes No. 582, St. Paul, Minn., The Station, 1960. 2 p.

In the prodn. of charcoal by carbonizing wood in kilns, the time required to cool the kilns sufficiently to permit opening them after the carbonization was reduced from about 60 hr. to 13 hr. by cooling the charcoal by means of water sprays. 2 ref. (A.B.I.P.C. 30:12)

TESTING AND ANALYSIS

Vakin A. T. The determination of moisture in fresh wood. Izvest. Vysshykh Ucheb. Zaved. Lesnoi Zhur. no. 1: 126–31 (1959) Referat. Zhur., Khim. no. 21: 447 (1959). [Russ. Abstr. only available]

Expts. were conducted to test the accuracy of moisture detns. of wood, sampled by means of the Pressler drill. It was found that detn. of sapwood moisture gives usually too low values, except at high moisture contents (above 200%), when the values are too high. For moisture contents near to the point of satn., the error is insignificant. At moisture contents of 40–60 and 100–140%, the loss of water caused by squeezing out during sampling is 10 and 34–48%, resp. At moisture contents equal to or higher than 200%, this value becomes negative (—9%). It is suggested that the exptl. errors are detd. by the diam. of the drill and the degree of sharpening of the cutting blade. To obtain true moisture contents, correction of the exptl. values, calcd. for different moisture levels, is recommended. (A.B.I.P.C. 30: 12)

LIGNIN

K. Kratzl and J. Gratzl (Austrian Inst. for Wood Research) Holz-Forsch. u. Holz-Verwerts, 12, 8-14, 1960. Thermal degradation (hydrolysis) of lignin results in a reduction in phenol-aldehyde yield (I). This sets in quickly and after 20 hours at 200° C., I approaches a constant value. At same time, but at a much slower rate, a MeO-containing "phenol polymer" is formed. The orgin of this residual phenol aldehye seems to be the thermal stable, water soluble decomposition products of guaiacyl glycerol-β-ether groups. Using this technique of measuring I, authors compare reactivities of various types of technical, special and model type lignins. Irradiation of Willstatter lignin (Co^{60}) with 52×10^6 R results in about an 8 percent reduction in I.—H. Tarkow

WOOD PROPERTIES

Dadswell, H. E. Wood structure variations occurring during free growth and their influence on properties. J. Inst. of Wood Science (Australia) 1:24 p. (March, 1958).

The three main stages of the life of the tree,namely, the youthful or immature period, the adult or mature period, and the senescent or overmature period, are discussed in relation to the variations in wood structure that occur and the influence of these on props. and timber utilization. The evidence brought forward shows, among other things, that, in the immature period, cell dimensions and cell wall organization are changing rapidly with consequent changes in certain props. and that, in the mature period in hardwoods at least, minute compression failures are formed at the center of the stem and for some distance radially as a result of growth stresses. The devt. of minute compression failures in association with reaction wood formation, also as a result of growth stresses, is discussed. It is pointed out that the changes in structure and props. in the wood formed during the early years of the tree's life influence the utilization of young trees, thinnings and tops from plantations and regrowth forests. On the other hand, in the utilization of timber from mature trees, the effect on props. resulting from the transformation of sapwood into heartwood, from growth stresses, from reaction wood, and from the devt. of heart rots are important. It is stressed that reaction wood formation may result from any of a no. of external influences and the changes in structure due to its formation are superimposed on the changes occurring during the normal life of the tree. Reference is made to the differences in the cell wall organization of compression wood and tension wood in relation to that of comparable normal wood and, in the case of tension wood, to the relation between its cell wall organization and the troublesome props.—irrecoverable collapse, woolliness, and longitudinal shrinkage. The possibilities of influencing changes in structure and, therefore, in props. by selective tree breeding, are discussed. 4 ref. (A.B.I.P.C. 30:12)

WORLD-WIDE
Forest Products News

ORGANIZING FOR

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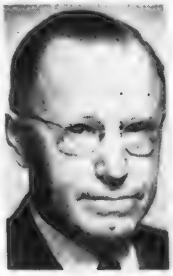

GEORGE M. HUNT

Forest products research can be exceedingly beneficial and profitable to any country that needs it, if the research institution and program are of a size and character to meet the needs of the country.

IN A NUMBER OF COUNTRIES NOT now provided with institutions for forest products research, there appears to be a growing appreciation of the need for such study, and a desire to organize and equip for it. Every country that has a substantial forest industry should have an office staffed with competent people who can keep abreast of the world knowledge in this field and carry on an educational program to adapt that knowledge to the needs of the country. In some instances, this may be all that is needed. In a country that has large amounts of timber of its own, however, a well-considered program of research and industrial development should be provided and should include the functions of the information office. Under such conditions, the problem is to determine the size and character of the research program required to meet the need without exceeding the capacity of the country to support it.

Research by Schools and Industries

There are, of course, various ways in which forest products research may be carried on. It can be done piecemeal by professors in colleges of forestry, engineering or chemistry, in their spare time. Some very good work can be done in this way and it should be encouraged, but it will usually be completely uncoordinated and often of little industrial value. Furthermore, this method does not provide for a center of information.

Private industries of large size such as pulp mills or large sawmills, plywood factories, and the like should and sometimes do carry on research for their own benefit. If their research results in better products, lower costs or more complete utilization, the research is good for the country. In industrially advanced countries, much research is accomplished in this way and the results are often published after they have served their private purposes. Such research is very selective and primarily for the benefit of the company that pays the costs. The benefits to the public is incidental and usually delayed. It is not a suitable method for a country needing basic information on the properties and characteristics of its native woods or wanting to educate its people in wood utilization, protection, and waste.

Private research foundations independent of industry can do research in forest products as well as in other fields, but generally only by individual projects of limited scope. Such institutions are seldom found except in industrially developed countries. It is possible, of course, to send wood to such institutions from other countries for investigation, but these institutions do not adequately meet the needs of a country especially the need for a center of specialized information and consultation freely available to the public.

Forest Products Laboratories

In countries where there is a need for forest products research and information, the need can be met through some form of publicly supported research institution. There are various ways in which such an institution may be organized and administered. For example, it may be a separate institution reporting at a high governmental level, a branch of a government college of forestry or bureau of forestry, or a segment of a research institution covering a wider field. The form that is best in any country will depend upon the conditions existing in that country and the general arrangement of its governmental and research functions. The greater the degree of subordination of forest products research to other interests, however, the less it is likely to accomplish. The outstanding forest products laboratories of the world are those that are devoted entirely to forest products research and are fairly autonomous although reporting to a forestry service, a university, or a national council for scientific and industrial research. In research institutions where forest products is only one of the fields covered, the total amount of time available for forest products will usually be so small that progress will be slow and the field will not be adequately covered.

The size of a forest products research organization should depend on the importance of the subject to the country and the ability of the country to support it. Careful study and planning are required to arrive at the right compromise between too much and too little. This should include an objective survey of the needs of the country for research and the probable value to the country of research programs of different sizes. The survey should include consideration not only of the size of institution and program than can be started, but whether it can be maintained. It is not wise to start a broad program covering many projects only to have it emasculated in a few years by lack of financial support or of qualified personnel to carry it on.

A very important function of a forest products laboratory is to develop a corps of specialists who can serve as consultants to the public as well as be leaders of research in their respective

[1] Presented by title at the Fifth World Forestry Congress, August 29—September 10, Seattle, Wash.

The Author: Formerly Director of the USFPL, Madison, Wis., Mr. Hunt became consultant to the Philippine government in 1954, to help establish the new Forest Products Laboratory at Laguna, where he has served as consultant and advisor since that time. He is a founder and charter member of FPRS.

fields. A group of specialists working together can be much more effective than the same number of equally competent specialists working independently of each other. The combination of different skills applied to a common problem makes for great progress and fewer mistakes.

Administration

The accomplishments and usefulness of any forest products research institution, regardless of form or size, will depend largely upon the technical skill with which it is administered and maintained. The purpose of the entire administrative staff of the institution, from top to bottom, should be to facilitate and expedite the real work of the organization in research and development and in public education and consultation. Too frequently, however, administrative personnel are inclined to become dictators and to feel that their work and requirements are more important than anything else. Then research is hampered, the freedom of the researchers is unduly restricted, the workers are discouraged and progress is delayed.

A forest products research institution cannot usually be completely independent, but its director and workers should have the maximum permissible autonomy in handling their business and technical affairs. Unnecessary regulations, restrictions and delays in making needed purchases, appointments, promotions, contracts and decisions, or in ridding the staff of unproductive or undesirable personnel will reduce the ability of the institution to accomplish its objectives. Rules, regulations, and supervision are necessary, of course, but they should be kept at the minimum consistent with good management.

Early Work of the Laboratory

During the early years of a forest products laboratory, its work must consist largely of two types (a) becoming familiar with the accumulated world knowledge in the entire field of forest products, and adapting this information to local problems, and (b) determining the basic properties and characteristics of native woods in order that they may be used to best advantage. This work will be largely empirical, but may include investigations of special local problems of utilization or processing. There will be little opportunity at this stage in the life of the institution to do highly scientific research to extend the boundaries of world knowledge.

The continued financial support of the institution will depend to a considerable degree on its showing "practical" results. Highly scientific research that does not have immediate application is not likely to impress budget and appropriating officials as much as research to meet a current national need. Furthermore, very few if any members of a new institution in an underdeveloped country are likely to be qualified in the beginning for anything more than the empirical type of research. Ability to do more scientific work will increase with experience and particularly with postgraduate training to higher academic degrees. This type of training is highly important to a growing institution and must be obtained if the institution is to approach the scientific level of similar institutions in technologically advanced countries.

The Research Program

Much administrative skill and judgment will be required in selecting and guiding the research program year by year to insure that the main effort is applied on investigations to meet urgent national needs and not merely to satisfy the current curiosity of some worker or inquirer. The program must include long-time projects as well as those of short duration. Examples of long-term projects are determining and cataloging the mechanical, chemical, and physical properties of local species. This provides basic information constantly needed in determining the fields of usefulness and the limitations of individual species and in answering the innumerable questions that will be asked by the public. Such research amounts to getting the answers to questions before they are asked. Examples of short-term projects are (a) determining why the veneer of a certain species is difficult to glue, (b) helping a manufacturer select the best species of wood for the manufacture of venetian blinds, or tool handles, or some other specific project.

In all its basic testing work, it is highly desirable for a new institution to follow closely established international standards. Only in this way will its test data be comparable with those of institutions in other countries. With increased experience and competence, an institution may begin to take part in the general search for improved methods and standards, but attempting this too soon may result in confusion and loss of confidence. Special problems, of course, may require special methods for their solution, but this is not true of the general accumulation of data on chemical, physical, mechanical and other properties of species.

Another precaution of major importance is the thorough authentication of test material used in testing for basic properties. The surest way of obtaining wood for testing that is fully authenticated as to species and is representative of the species is to select the tree in the forest and have it felled under the observation of a competent man who will select botanical samples and save them as evidence of the correctness of identification. Selecting test material at random from lumber yards may be permissible at times for some kinds of testing, but not for the task of establishing the basic characteristics of an important species.

Joint Laboratories and Programs

While it is not usually practical or profitable for small countries to support a big forest products laboratory with a full program, consideration could be given to the possibility of establishing a large joint laboratory under international control to serve several countries with similar forests and utilization problems. It is appreciated that national pride and language difficulties can interpose many obstacles to the success of such an international institution. Nevertheless, it should be possible in some instances for an organization of this kind to succeed and to be more useful to all the countries concerned, rather than each country to spend the same amount of money on a small institution of its own, inadequately staffed and equipped.

Another possibility for neighboring countries with similar species and problems and each supporting a small laboratory would be for each laboratory to specialize in a different field while covering other fields in lesser degree. For example, one laboratory could specialize in pulp and paper manufacture and accumulate the expensive equipment needed for this purpose. Another could specialize in research on saws and sawing, which again requires expensive equipment and highly specialized knowledge. Another could concentrate on entomology, pathology, and wood preservation, and another on seasoning or some other important field. Thus each laboratory could retain complete freedom of action and go as far as desired in covering other fields. By constant exchange of information and joint consideration programs, they could greatly supplement each other's work and together make greater progress, serve their respective countries better, and gain greater prestige.

In short, forest products research can be exceedingly beneficial and profitable to any country that needs it, if the research institution and program are of a size and character to meet the needs of the country, and if the instruction is organized, supported and administered wisely.

Canadian FPL Tests Cross-Ties, Bolters

Wooden Cross-ties

Recognizing the difficulty associated with seasoning wooden railroad cross-ties, the Ottawa Laboratory, Forest Products Laboratories of Canada, in co-operation with the Canadian National and Canadian Pacific Railway Companies, have been examining alternative methods of seasoning cross-ties during the year. One approach which looks promising, on the basis of preliminary work, is the application of high temperature seasoning. Hard maple ties have been subjected to temperatures of 230° F. under varying conditions of humidity, and drying has been accomplished to 50 to 60 hours from the green condition to 30 per cent moisture content. The quality of the seasoned ties was good, and subsequent pressure treatment with creosote indicated that no special problems were encountered. A number of these ties have been returned to the railways where they will be placed in track, and records of their service life will be kept. Although final assessment of this method of drying ties will be made at a later date, the application of high temperature seasoning to this product looks promising.

The Short-Log Bolter

Technical Note No. 10, "The Short-Log Bolter—Its use in Conversion of Canadian Woods" contains information of interest to industries utilizing Canadian hardwoods and softwoods. This publication gives results of studies at a number of mills in Quebec as well as data obtained at the FPLC Research Sawmill in Ottawa.

Figures showing representation of profit margin and costs favor the bolter in comparison with the sawmill in the production of some forms of lumber. Tables are presented indicating that the sawing accuracy of the bolter is comparable with that of the following 2 types of equipment—the round log gang saw and the cant gang saw. Examples are given of yields of dimension stock which can be recovered from logs and bolts of varying size. Generally it was found that in the bolter mill it was possible to recover a substantially greater percentage of the log volume than was possible in the sawmill.

It is pointed out that there is room for increased use of the bolter in the conversion of softwood species. Bolters can be and are often used in softwood sawmills to recover clear pieces from slab material.

Bucking Hardwood Sawlogs

Recently the Ottawa Laboratory conducted a hardwood log grading study in co-operation with the Singer Manufacturing Company, Thurso, Quebec. The multi-use operations carried out by this company were ideally suited to study the extent by which log values can be increased by employing a knowledge of log grading techniques as compared with conventional methods of bucking hardwood sawlogs.

Although the final analysis of this study has not yet been completed, preliminary results indicate that the application of hardwood log grading techniques to the manufacture of birch and maple sawlogs in Eastern Canada should bring substantial benefits.

Tropical Timber Market Increases

An FAO technical assistance officer broadcasting from Borneo described the present prospects for ramin timber (Gonystylus spp.) Generally, he said that there is quite a demand in Europe for woods that are light to moderately light in weight and whitish to yellowish white in color. Ramin, which comes from Sarawak, Borneo, is one of the few such woods available from the tropics. This wood machines well, so that it can be used for fine moldings; it finishes well and takes paint easily, and it behaves well after manufacture, which is to say that it does not warp and shrink as much as many of its competitors.

Sales to Europe have been expanding during the past years. The Sarawak ramin trade now has plenty of experience of world market conditions, and is aware that a firm and steady market can be ensured by sensible selling through reliable agents aboard.

The technique of extra action of ramin by light rail through swamp that has been developed in Sarawak enables the timber to reach sawmill and port at moderate cost. It was the development of this technique that made it possible to market ramin overseas.

The strong entry of Japan into the Sarawak log market is almost certainly due to events in the Philippines. Japan has been a tremendous purchaser of lauan from the Philippines, and this lauan has been the mainstay of the Japanese export plywood trade, which is for the greater part with the United States. The Philippines is now building up its own plywood industry and needs the logs once exported to Japan. Over a period of 5 years, the Philippines intends reducing log exports, particularly of veneer quality, by 50 percent. Japan is looking elsewhere in Southeast Asia for logs to replace the falling Philippine supply. Great quantities are being obtained from North Borneo, Viet-Nam, Thailand and Indonesia. Provided Sarawak can supply Japan with the kind and specification of logs that she needs and at prices that are competitive, there seems to be no reason why the present level of log purchases from Sarawak should not continue, and even increase. (Unasylva, Vol. 14:2)

Research Conducted For Finnish Plywood Industry

At the Cologne furniture exhibition in 1960, 15 Finnish furniture manufacturers, members of the Council on Furniture Export Promotion, will present their furniture products for buyers to assess.

Finnish plywood factories are to establish an association in London to carry on market research in England and find new uses for birch plywood. The association will lay special emphasis on publicity and public relations. The results of this extensive research will show the Finnish plywood industry what new qualities should be developed and into what new fields it should expand. The findings in the United Kingdom, which is Finland's principal export market for this commodity, can be adapted for other countries, so that the result of the work there will be of prime importance for the whole of the exports in this line. (Unasylva, Vol. 14:2)

World's Softwood Trade Increased 10% Last Year

The total world exports and imports of sawn and planed softwood in 1959 balanced at a rounded-off average of 6.9 millions standards, as compared with 6.3 million stds in 1958, 6.4 million in 1957, and an annual average of 5.7 million for the pre-war years 1934–37, the *Swedish Timber and Wood Pulp Journal* reports. While the European turnover showed an average increase of 500,000 stds, or 13 per cent over 1958, the combined increase in other parts of the world did not exceed 100,000 stds, or 4 per cent. As regards exports, European shipments showed a net increase of just over 500,000 stds, almost entirely accounted for by Sweden (151,000 stds), Finland (196,000), and the Soviet Union (165,000). In the non-European sector, where exports were up by only 90,000 stds, Canadian shipments rose by 100,000 stds and U. S. exports by 30,000 stds, whereas Brazilian exports declined by 45,000 stds.

Swedish Aero Clubs Used For Fire Detection

A news item from Sweden states that 137 amateur pilots flying 41 private aircraft from altogether 12 areo clubs took part in the forest fire supervision of north and central Sweden during the fire season of 1959. The scheme of employing private aircraft in fire detection was started in 1955 by the Royal Aero Club, and supervision, normally handled by ground spotters in high towers, has now been partly taken over by the sports flying clubs.

Each club is responsible for its own district and organizes a voluntary flying group of 3 to 6 aircraft. The leader of the group decides whether it is necessary to fly or not, or how often, according to the fire risk values broadcast every morning by Radio Sweden. (Unasylva, Vol. 14:2)

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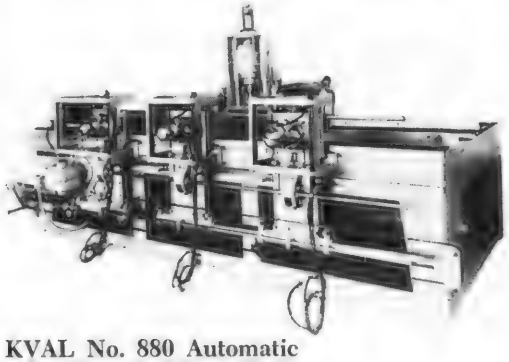

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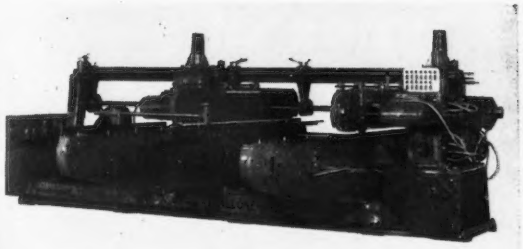

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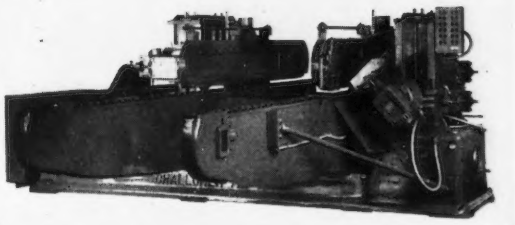

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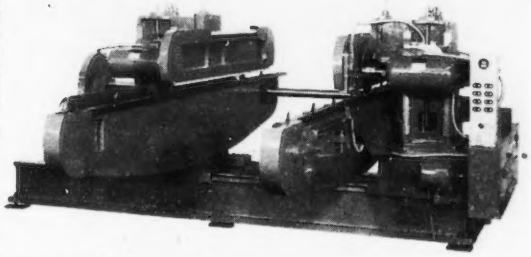
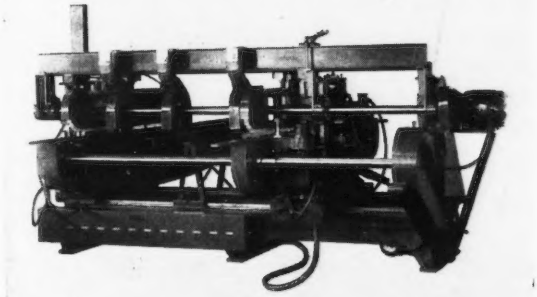


CHALLONER No. 520
Everywhere



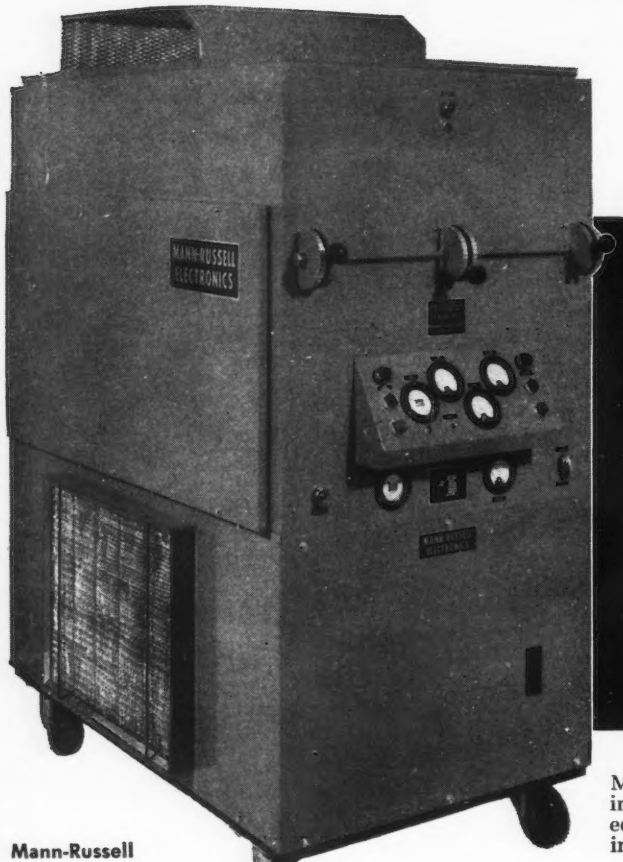
CHALLONER No. 527–TS
Everywhere

Next in line CHALLONER No. 723 Multi Post ask about it

All equipped with the same Vee type feed chains, plastic Vee Tracks and 8-point Sprockets

Manufactured by CHALLONER MACHINERY CORPORATION
Oshkosh, Wisconsin

Formerly C. K. L. Machinery Company



Mann-Russell
Model 700
Generator
20 kw output

All types of ELECTRONIC GLUING EQUIPMENT

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- Veneer Edge Gluers
- Plywood Panel Patchers
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- Particle Board Scarf or Edge Gluers
- Lumber Scarf Gluers
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- Shingle Edge Gluers
- Shake Panel Gluers
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"Mattison automatic lathe does top job on over 3000 patterns... permits us to turn and deliver in one day"

J. R. Carrick, President
Carrick Turning Works, Inc.
High Point, North Carolina

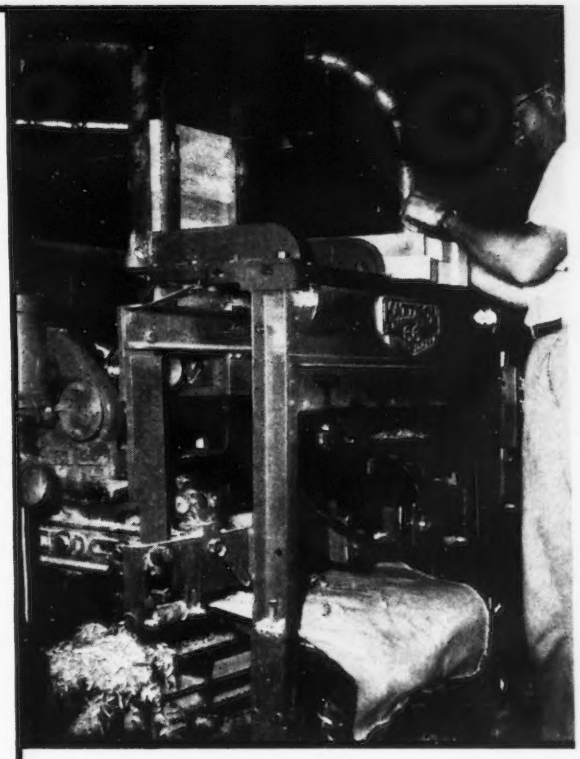
Low-cost turning is important to any woodworking operation, but for Carrick Turning Works it directly determines profit. Carrick is one of the largest plants in the country that devotes all of its production to turning. They deliver over 4,000,000 precision turnings a year from more than 3,000 patterns for the furniture industry.

One-day delivery from receipt of order is common for some patterns. All output is on special order and no turnings are produced for stock. Carrick can't afford anything but the best in turning lathes. They use 16 Mattison automatic lathes.

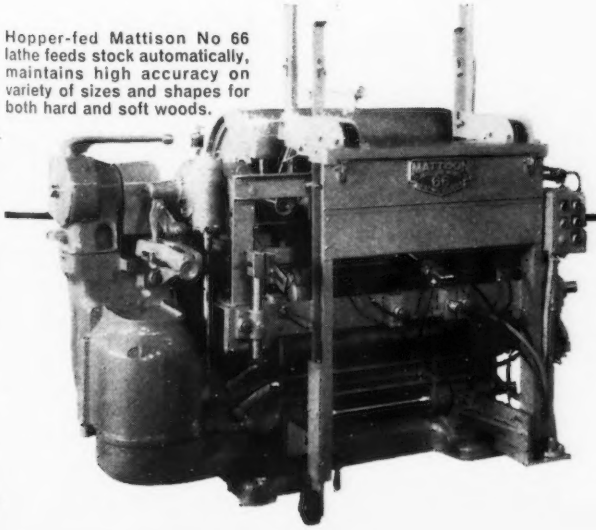
In describing his company's unique operation, J. R. Carrick comments, "Because we manufacture turnings only according to customer specifications, we have numerous patterns of various sizes and shapes, and continuously use hard and soft woods. The Mattison No. 66 does excellent work on all of these.

"We also find that there is less downtime because the knives stay sharp longer. This is because the cutters are automatically removed from the turning when the correct size is reached. There is no rubbing to dull the knives as with manually operated lathes."

If you need fast, precise wood turning with minimum supervision, the Mattison No. 66 automatic shaping lathe offers a direct opportunity to reduce turning costs.



Mattison No. 66 automatic shaping lathe handles stock from ¾" to 4" square and up to 30" long. One man can easily keep two lathes in operation simultaneously.



Hopper-fed Mattison No 66 lathe feeds stock automatically, maintains high accuracy on variety of sizes and shapes for both hard and soft woods.

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MACHINE WORKS
ROCKFORD ILL. U.S.A.

MATTISON

WOODWORKING MACHINERY

"Built better... to produce better quality"

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COME IN A COMPLETE RANGE OF SIZES

INDUSTRON
HIGH FREQUENCY

"ONE MAN" MODEL E SIDE FEED ELECTRONIC EDGE GLUER

• RAPID and EFFICIENT EDGE GLUING with a MINIMUM of LABOR and SPACE • GLUE STOCK UP TO 3" THICK and in PANEL SIZES from 48" x 50" to 50" x 100" • ONE OPERATOR: FEEDS GLUE SPREADER, LAYS UP STOCK, REMOVES GLUE STOCK and STACKS IT ON TRUCK • MANUFACTURE LUMBER PANELS from ALL SPECIES OF WOOD.

"One Man" and Industron's Model E Edge Gluer combine to meet the output of a three to four man crew with clamp carriers. One operator easily handles the entire process because he does not use his time to spread glue, hammer stock and tighten clamps; the automatic glue spreader and press do these operations for him.

The Industron Model E machine with its more than ample top and edge pressure produces flat panels with practically invisible joints. To cover the scope of production requirements Industron manufactures a complete line of sizes of Side Feed Electronic Edge Gluers.

A Proven . . . High Performance . . . one man gluing operation with a minimum of labor and space. This is what owning an Industron Model E Side Feed Electronic Edge Gluer can do for your operation. "HIGH FREQUENCY POWER" in combination with the specially designed "one man in the center" INDUSTRON EDGE GLUER is the secret of the high efficiency and large production you can expect with an Industron machine.

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